

Scope This document is about creating drawings that help you build models. My intention is to highlight a few concepts and techniques that I think are important. My discussion assumes an understanding of basic drafting skills, perspective, and light and shadow. If you would like to see a complete treatment of these topics the books listed below would be a good place to start.

References **Designer Primer**
Tom Porter & Sue Goodman, Charles Scribner's Sons, 1988

Drawing: A Creative Process
Francis D.K. Ching, Van Nostrand Reinhold, 1990

Design Rendering Techniques
Dick Powell, Northlight Books, 1986

Engineering Drawing and Graphic Technology
French & Vierck, McGraw-Hill Book Company

Tools CAD is the best tool for creating precise working drawings. However, unless you are really fluent with a particular software package, you will probably be able to sketch out ideas and rough plans faster and with more fluidity by hand. For this reason a good approach to creating your working drawings is to do some preliminary work by hand first, and then move onto the computer once your design is established.

Paper
Any paper will do for sketching, including the oft-mentioned back of an envelope or cocktail napkin. However, for the sake of your sanity and good process I strongly recommend that you purchase a bound blank book and keep all of your notes and sketches in it.

Pens
You need pens with three different line weights. Black ink eliminates the distraction of color, and guarantees high contrast drawings which are easy to read and photocopy. I use rolling ball-type pens for my finer lines and felt-tipped or markers for thicker marks. I don't use Sharpies for drawings because the ink becomes greenish over time, and leaves a yellow phantom on the facing page of your book.

I use pencil only rarely for making plans, and then I go over it with ink as soon as I like what I have drawn. Pencils smudge, are hard to read, and don't photocopy well. Some people sketch with a photo blue pencil first because these lines don't photo copy at all. I don't do this because I like to see my construction lines.

Measuring
I keep a tape measure and a calipers nearby when I am sketching plans
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because I often need to get an idea of how large (or small) the thing I am designing will be.

The following techniques can make your drawings easier to understand.

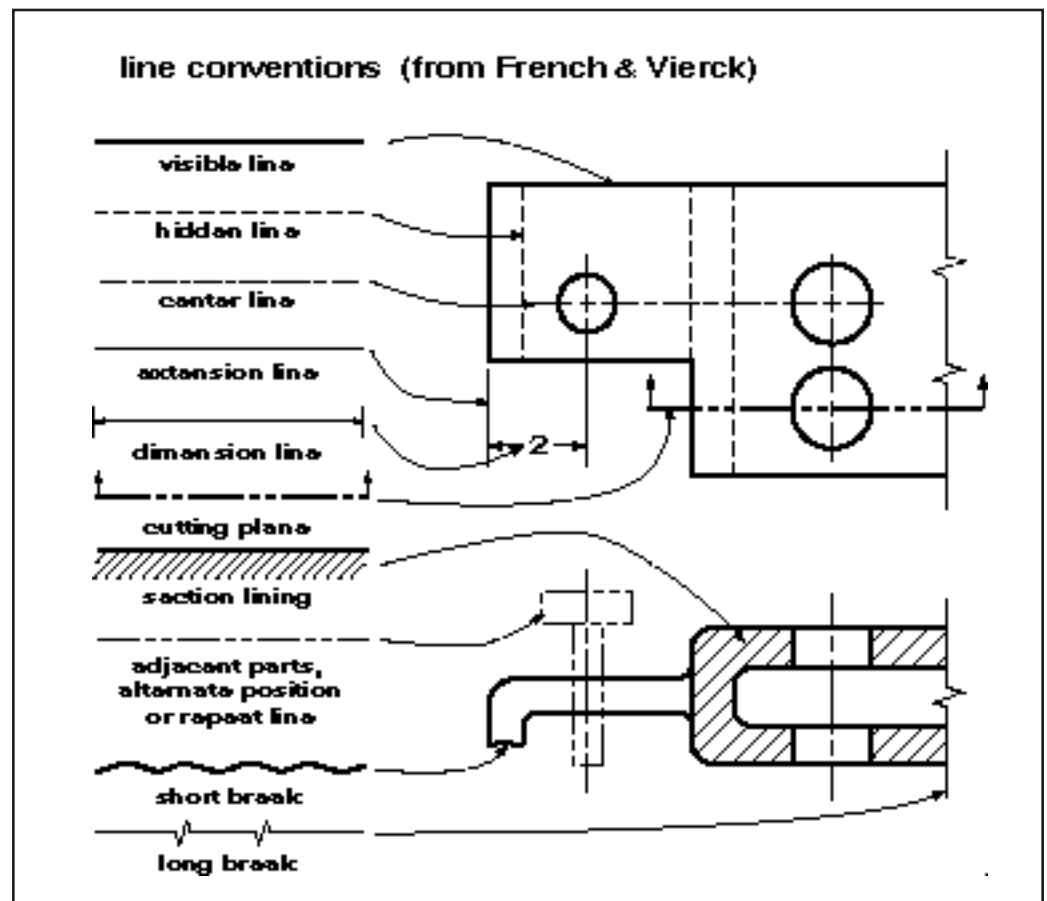
Style

Line Weight

One of the simplest ways to achieve both clarity and punch in your sketches is to make use of different line weights. Three is generally enough. Basically, the idea is that the more exterior the line, the thicker. It is important to be consistent in your line work. Once you designate a line as a certain thickness, then you need to identify all the logically similar lines in your sketch and make them the same weight.

An excellent way to learn how to use line weight effectively is by studying cartoons and comic books. Gary Trudeau of Doonesbury and Bill Watterson of Calvin & Hobbes are examples of cartoonists who are excellent draughtsmen.

When doing part drawings (discussed below) you should get in the habit of using the established line weight and style conventions.



Shading and Shadows

Shading is generally not included in formal part drawings, but for quick sketches and working drawings a bit of shading can be very helpful. Shading helps define volume, texture, and the boundaries between forms. When you are trying to work out a complicated structure, adding shading can help you "see" in your mind's eye what the correct relationships should be.

Three different tonal values is usually plenty for sketches and often two is

enough. Just as in line weight, you must be consistent; shade the same sides of your objects the same way.

Use shadows to help you see the breaks between surfaces or the relationship between parts. Shadows can also function a bit like vignettes; they establish a foreground and background in your sketches.

A Word About Clarity

Working drawings are for getting ideas down quickly, solving problems before moving to three dimensional materials, and exploring. Because they are often intended only for personal use, it would seem that one needn't be too concerned with clarity: if my thinking is a bit confusing what should that matter to you?

In fact, it does matter for at least three reasons. The first is that if your sketches are muddled and unclear it is quite likely that there will be important details you have ignored, or only partially solved. Second, looked at after even a few days, a sketch that was once clear to you can be suddenly confusing. Finally, and most importantly, it turns out that rarely is your sketch just for you. Your work can always be improved by sharing your ideas with others, and clear sketches make sharing ideas much easier.

This having been said, you should not go overboard towards perfection either. Working drawings are meant for building things. Work to develop a style that is attractive, quick, and clear. You can always dress up the drawing later if the situation requires it.

Kinds of Drawings

Working drawings have, by convention, several different formats. Each is intended to show a different aspect of the object. You can use a combination of these different types to work out how to build a model.

Perspective

A perspective drawing can be very helpful in planning the construction of a model. Unfortunately, careful perspective drawings take a long time to do. Therefore, for planning your models you should learn to create a cliched set of shapes that you can quickly and convincingly draw in perspective. Practice drawing cubes, spheres and cylinders from one or two points of view. Because most forms can be built up from these primitives, once you can draw them, you can draw most of the things you can imagine.

Orthogonal

Orthogonal drawings present different views of an object with each view being 90° from the others. In this country the standard drawing is the right side drawing which consists of a front view, a top view and a right side view. The front view should be the most complicated view. The top and right side views should be arranged around the front view in the proper orientation. Additional views are shown only if the standard three do not communicate all of the essential detail.

The convention in the US for defining views is to imagine that for the front view the object is at the bottom of a bowl. The other views are found by sliding the object up the sides of the bowl. I believe that in Europe the convention is reversed and the object is imagined sitting on top of a sphere.

The orthogonal drawing will be the most useful to you when building models. Because no perspective is involved you can create these drawings rapidly and accurately. If the drawing is done carefully, and to scale, measurements may be taken directly from the drawing. When making an orthogonal drawing, leave room on your page to add other views. Once you begin construction, you may realize that you need

another view to figure out a particular detail, and you shouldn't have to redraw the sketch in order to add the view.

Layout or Assembly

A layout or assembly drawing includes all of the parts of your project in their final, assembled relationship. In producing mechanical part drawings, a layout drawing of the entire assembly is done first, and then is used to create the individual part drawings.

For the purposes of sketching plans to make models this type of drawing is not that useful. It rapidly becomes muddled with the lines for each different part and begins to confuse more than clarify. Of course, if you are working in CAD, you can use different layers or colors for each part to reduce the confusion. The hand analogy for this is to use overlays for each part, but unless you really don't have access to a computer you shouldn't be doing this.

Exploded

An exploded drawing shows all the parts of an assembly in their correct relationship but not in their correct position. The parts are exploded apart so that additional details about each part can be seen. The "explosion" is imagined to occur very neatly so that each part has moved outward in a straight line from its correct position.

This kind of drawing is often more helpful in planning a model than a layout drawing because the separation between the parts makes it less confusing. An exploded drawing can be either perspective or orthogonal. I recommend doing a perspective in the rough planning stage and orthogonal as you finalize your design. When you do the perspective version, however, do not attempt to be overly accurate; just put in enough detail so that you can figure out how to build the model.

Part Drawing

A part drawing is an orthogonal drawing of one part. It shows the dimensions of the part, and includes, as notes, other details required to make the part such as material, finish, quantity, etc.

Doing part drawings is the single most important thing you can do to create a successful model. These drawings serve several purposes. The first is to force you to be organized. In order to produce the drawings you will have to have fully designed your project. Drawing the three views of a part will mean that you have to think about all of its details from every angle. Dimensioning the drawings will mean that you have to consider how much material you will need.

Part drawings keep you calm. If you do your planning before you enter the shop, you are less likely to become overwhelmed by the pace and activity of those around you. A model shop at the end of a semester is a place of fear, tension, and stress. The best way to maintain your cool in these conditions is to be working from plans you can trust.

Finally, part drawings help you make parts. You will know what you need to produce so you can plan how to make it. You can also figure out where you need help.

Annotations increase the amount of information contained in a drawing. A picture may be worth a thousand words, but pictures and words together tell a more complete story.

Dimensions

Annotation

The most obvious example of this is dimensions. Once something has been dimensioned correctly it can be made, before that it can only be discussed.

Your goal should be to dimension only to the level you need to make the part. However, you obviously don't want to make a mistake because your dimensioning was inadequate. The basic rule is the more things that have to fit together, the more careful you must be. You will also have to add more detail if you want someone else to understand your drawing.

One concept that is essential to good dimensioning is the datum. The idea here is simply to make sure that all your measurements share a common reference point. In your drawing you designate a certain feature on the part as (0,0) and show all dimensions from that point. As you build your model, you make all measurements from that same point.

The second important concept is tolerance. Tolerance is the amount that a dimension can vary. The greater the tolerance the more a measurement can vary without causing a problem. When you dimension your drawings and when you make your models you will need to decide how much tolerance is acceptable. You base this on the level of finish you want in the model, the tools you will be using, and the particular qualities of your material.

Notes & Call Outs

Notes are comments which explain your drawing. They can explain the object itself, how it is used, what it is made from, or any other relevant detail. Call-outs are just notes attached to arrows or lines so that they can refer to a specific part of the drawing.

You will need to add more notes if you want other people to understand your drawing. However, it is a good idea to add more than you think necessary even for yourself because when you come back to the drawing later you may have forgotten what you were thinking.