Introduction to CAD

Contents

What is CAD?

- CAD – Computer-Aided Design / Computer-Aided Drafting
- A computer program that allows a user to draw and analyze 2- and 3-dimensional objects
- Used in civil engineering, surveying, mine planning, construction, etc.

Cad Platforms Compatible with Carlson

IntelliCAD Technology Consortium	IntelliCAD - Only one type available - Included with any module of Carlson Software

AUTODESK® AUTOCAD®	AutoCAD
	- Many types available
	   o AutoCAD
	   o AutoCAD Civil 3D
	   o AutoCAD Map 3D
	- Must be purchased separately
	- AutoCAD LT is not compatible with Carlson Software

Carlson Software

- Specializes in CAD software, data collection, laser measurement hardware, and machine control products
- CAD software is essentially a plugin for IntelliCAD or AutoCAD for specific design work
- Divided into distinct modules for various applications

Survey	CADNet
Civil	Field
Hydrology	Natural Regrade
GIS	Point Clouds
GeoTech	Geology
Construction	Underground Mining
Trench	Surface Mining

CAD Introduction

Startup Wizard and Model Space
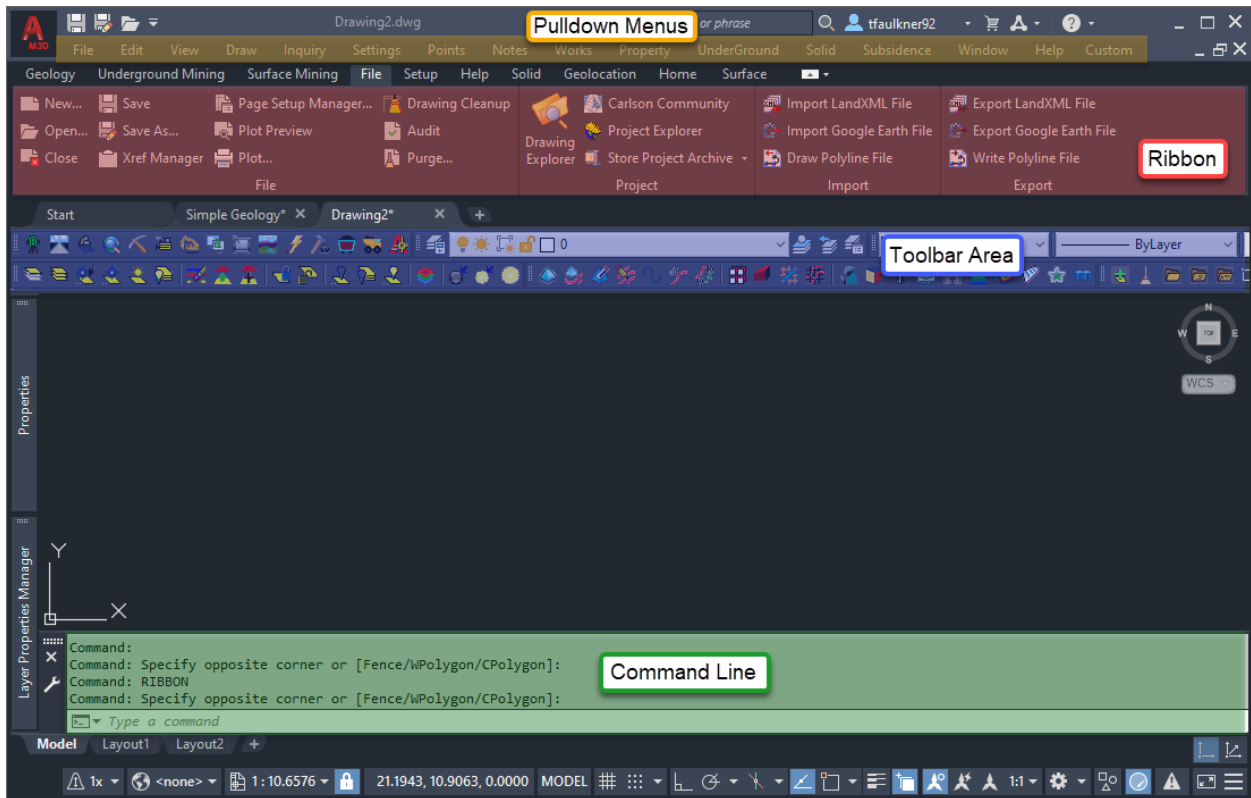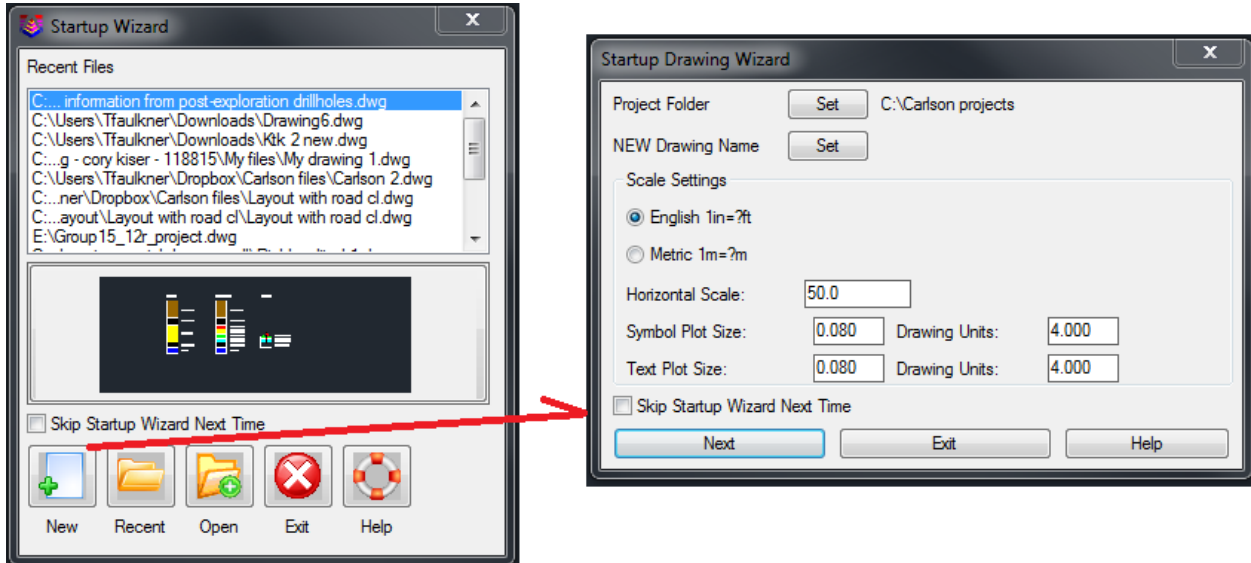
Drafting

Drafting – a synonym for drawing

CAD operates on a Cartesian coordinate system, which uses basic X (left/right) and Y (up/down) coordinates on a rectangular grid. We can use this to tell the program how to draw an object. Here we will draw an object using the endpoint coordinates.

Absolute Coordinates

1) Draw Pulldown Menu > Line (Alternatively, type 'L' into the command line and press 'Enter')
2) Accept the default settings by clicking 'OK'
3) Type in '0,0' and press 'Enter' to set one end of the line at the origin of the coordinate system
4) Type '10,0' to set the next point of the line at the coordinate (10,0)
5) Type '10,5' to set the next point of the line at the coordinate (10,5)
6) Type '0,0' to set the next point of the line back at the origin of the coordinate system
7) If the triangle is not shown on the screen, use View Pulldown > Extents (Alternatively, type 'ZE', which is short for 'Zoom Extents', into the command line and press 'Enter')

The result will be a triangle as shown below (Note: the coordinates will not be labeled as shown):
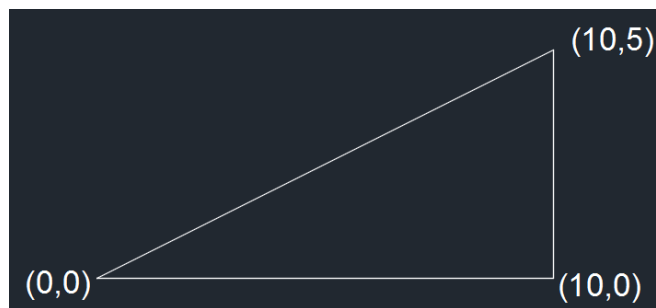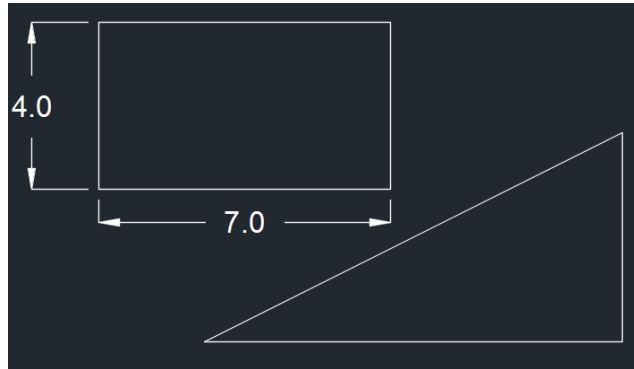
Sometimes we do not know the exact coordinates of the endpoints, but we do know the dimensions of the object. Here we will use relative coordinates instead of absolute coordinates.

Relative Coordinates

1) Draw Pulldown > Rectangle (Alternatively, type 'RECT' into the command line and press 'Enter')
2) Click somewhere outside of the triangle you just drew
3) Type '@7,4' to draw a rectangle 7 units wide and 4 units tall

The result will be similar to what is shown below (Note: the dimensions will not be labeled as shown):

Sometimes we do not know the relative coordinates in Cartesian form, but we do know them in polar form. For example, we want a line 4 units long to be drawn from the bottom left corner of the triangle at a 13° angle from the horizontal direction.

Relative Polar Coordinates

1) Type 'L' into the command line and press 'Enter' to draw a line
2) Type '0,0' into the command line to set one end of the line at the bottom left corner of the triangle
3) Type '@4<13' into the command line and press 'Enter' to draw a line 4 units long at an angle of 13 degrees from the horizontal

The result will be similar to what is shown below:
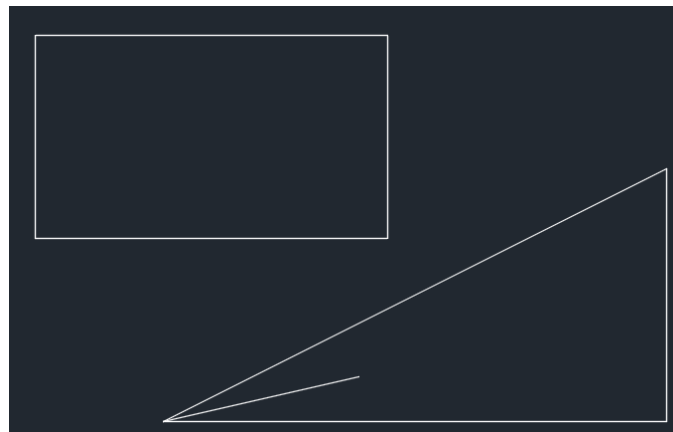
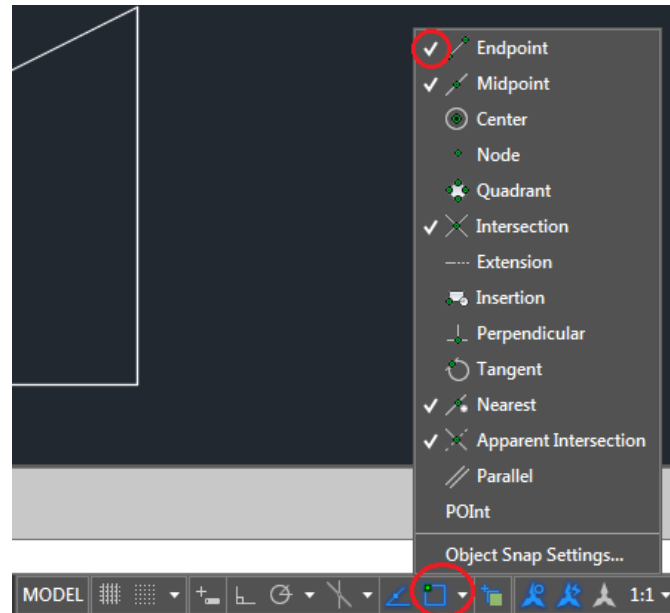Other times we do not know the coordinates or the dimensions of an object, but we know where it should be relative to other objects. Here we will draw a line connecting the top right corner of the rectangle to the top of the triangle using object snaps.

Object Snaps

1) Turn on the 'Endpoint' snap by using the Object Snap Settings at the bottom of the screen

2) Type 'L' into the command line and press 'Enter' to draw a line
3) Click the top right corner of the rectangle. Notice the rectangular snap indicator which appears
4) Click the top of the triangle, also taking note of the rectangular snap indicator

The result will be similar to what is shown below:
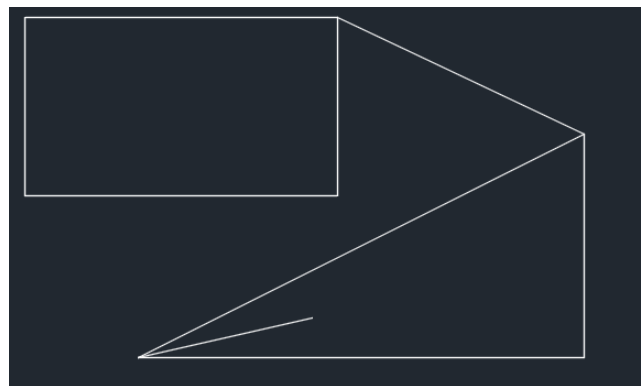
You can use any combination of entering absolute coordinates, relative coordinates, and picking points on the screen. Take note of the other types of object snaps available.

Object Grips

Sometimes we need to edit an object rather than redraw it. We can do this by using the object's "grips". Grips are identified by blue squares, circles, triangles, and rectangles. They appear when we select an object, as shown below:
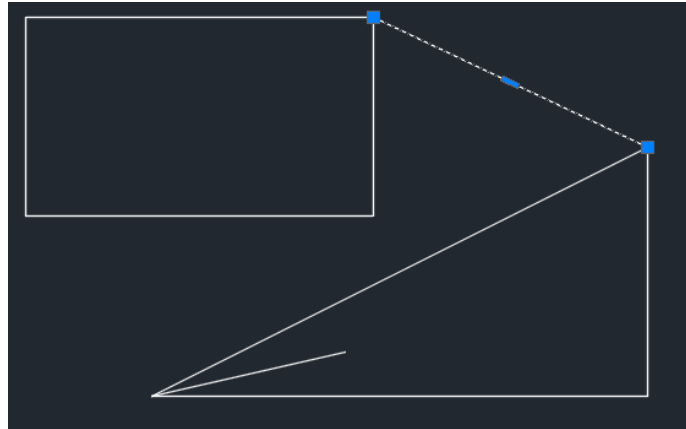

In the above picture, we have selected the line connecting the rectangle and the triangle. Notice the blue grips that appear. If we want to move the line from the top right corner of the rectangle to the bottom right corner, we simply click the grip and then click where we want to place it. The result of doing this is shown below.
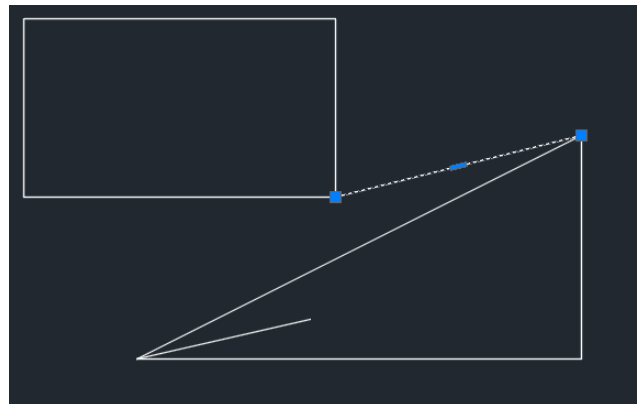
We can deselect the line, and thus hide the grips, by pressing 'ESC' or by holding 'Shift' and clicking the line.

Layers

Drawings can contain a great deal of information, which often overlaps. This makes it impossible to see all this information at once, so we need to be able to isolate certain pieces of the drawing quickly. This is done by using Layers. As the name implies, a Layer is one "level" of drawing information. Layers can be turned on or off to make the drawing more readable. Here we will look at creating new layers and placing objects on those layers.

Begin by typing 'LAYER' into the command line and pressing 'Enter'. This brings up the 'Layer Properties Manager', which lists all the layers in our drawing, along with the properties specific to those layers.
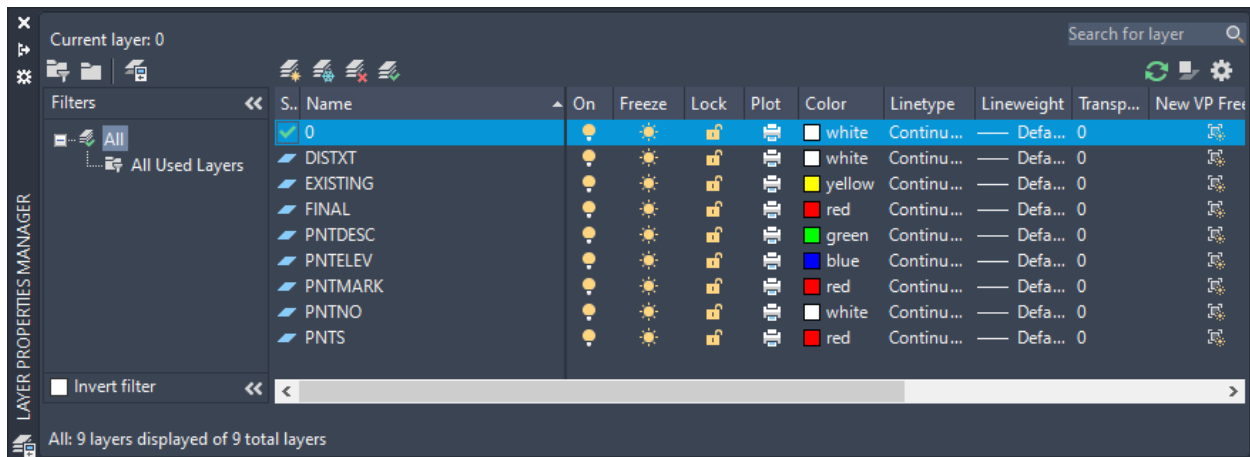
Here we see 9 Layers in the drawing. These are default layers that can be deleted if desired. The '0' layer, however, cannot be deleted. As the '0' layer is the primary default layer, it is good practice to keep objects off of this layer. Instead, we want to keep objects on layers with descriptive names so others will know what kind of information is on the layer.

Creating New Layers

Here we will make a new layer and draw objects on that layer. First, let's delete the default layers in the drawing. To do this, click on the layer and then click the 'Delete Layer' button (circled in red in the below picture). Next, we will create a new layer by clicking the 'New Layer' button (circled in blue in the below picture).
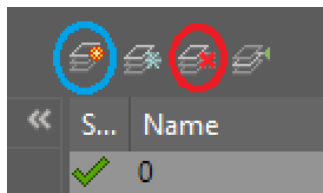
This creates a new layer with the name 'Layer1'. Change the name of the layer to 'Circles' by double – clicking on the layer name (pause between clicks). Change the color of the 'Circles' layer to green by clicking on the color block in the layer row (circled in red in the below picture). Change the linetype to 'DASHED' by clicking on the linetype in the layer row (circled in blue in the below picture). Finally, set

the current layer to the 'Circles' layer by double clicking on the layer icon (circled in yellow in the below picture). With the current layer set, any new objects we draw will be placed on that layer.

Try drawing some circles in/around the other objects. To draw a circle, type 'C' in the command line and press 'Enter. Notice how the circles are green and dashed.
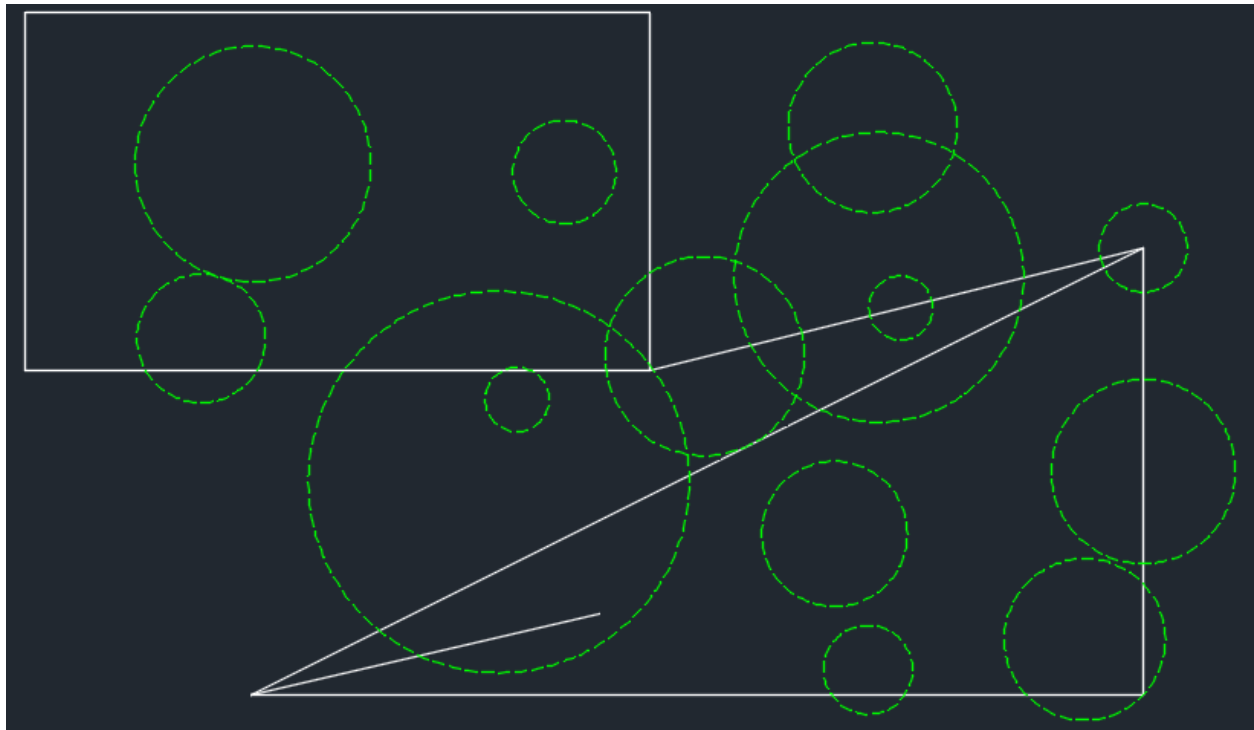
As shown in the previous picture, our drawing is now a little crowded. If we no longer want to see the circles, we can turn off the 'Circles' layer. This is done by returning to the 'Layer Properties Manager' and clicking the light bulb icon in the 'Circles' layer (circled in red in the below picture). This will give us a warning that we are about to turn off the current layer. Click 'Turn the current layer off'. You will notice when we do this that the green circles are no longer visible. Alternatively, we can 'Freeze' the layer by clicking the sun icon (circled in blue in the below picture).


When we turn a layer off, we make it non-viewable on the screen, but the program can still "see" it. However, if we freeze the layer, we make it "non-viewable" to the program as well. In general, it is better practice to freeze layers than to simply turn them off.

Placing Objects on a Different Layer

We will often draw objects and then realize that they need to be placed on a different layer. We can do this in several ways. Perhaps the simplest way is by using the Layers toolbar. To activate this toolbar, right-click in the toolbar area, hover over the AutoCAD Dropdown Menu, and click 'Layers' (this toolbar may already be shown, indicated by the checkmark next to the name).
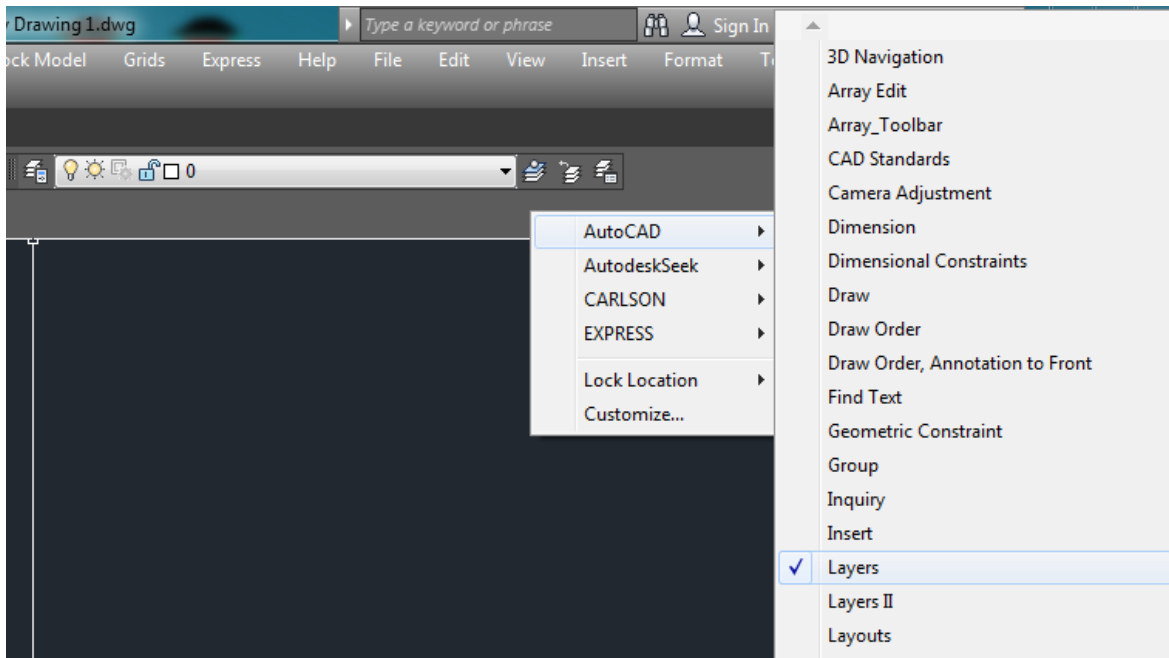
With this toolbar active, you will be able to see the layer information of objects you select. To change the layer of an object, simply select the object, click the toolbar, and click the layer on which you want to place the object. You will notice that when you place an object on a different layer, the object takes on the properties of that layer. In the below picture, you can see that three circles have been moved to the '0' layer and are now white with a non-dashed line.
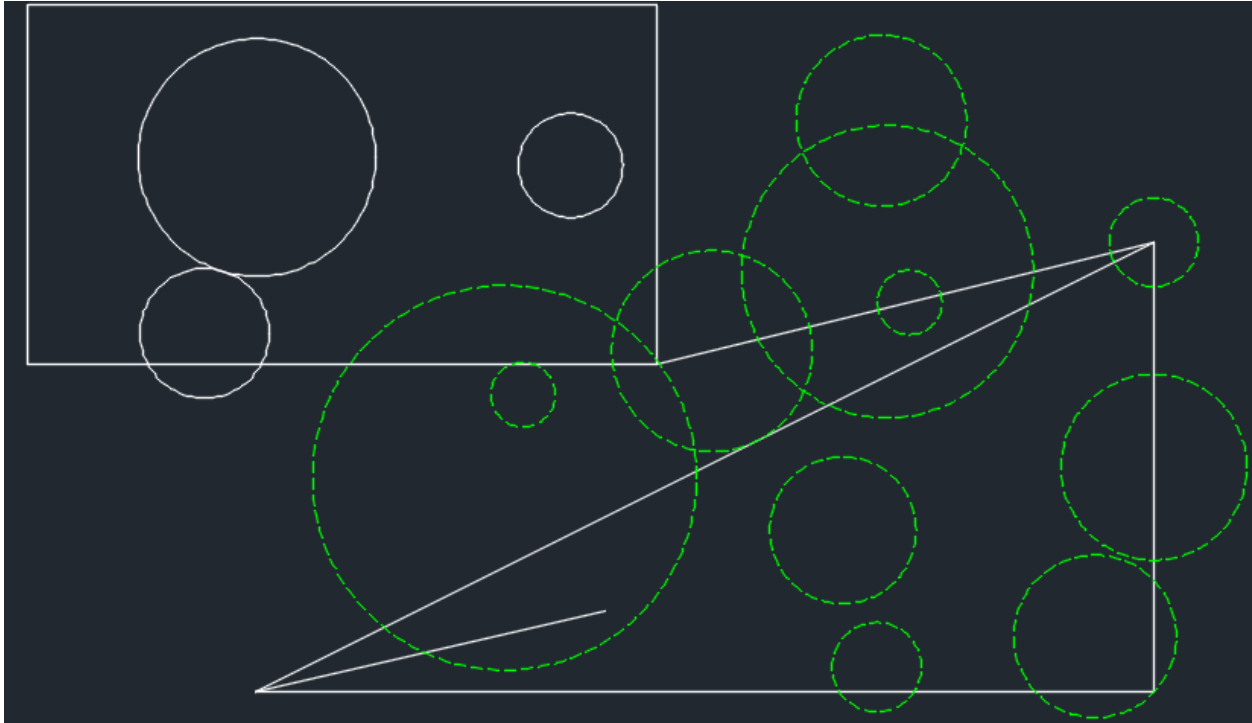
Non-Layer-Specific Properties

We don't always want all objects on a layer to have the same properties, which can be easily managed with the 'Properties' toolbar. This toolbar can be activated the same way we activated the 'Layers' toolbar. The 'Properties' toolbar is shown below:

Like the 'Layers' toolbar, this toolbar gives us information about objects we select. The above picture shows what the toolbar looks like when we select one of the green circles. Notice how each property shows 'By Layer'. This tells us that the selected objects will take on the layer-specific properties. However, we can change these options by selecting an object, clicking toolbar, and selecting the property we want the object to display.

In the below picture, several of the green circles have been changed to red with a dotted line type, but they are still on the 'Circles' layer.
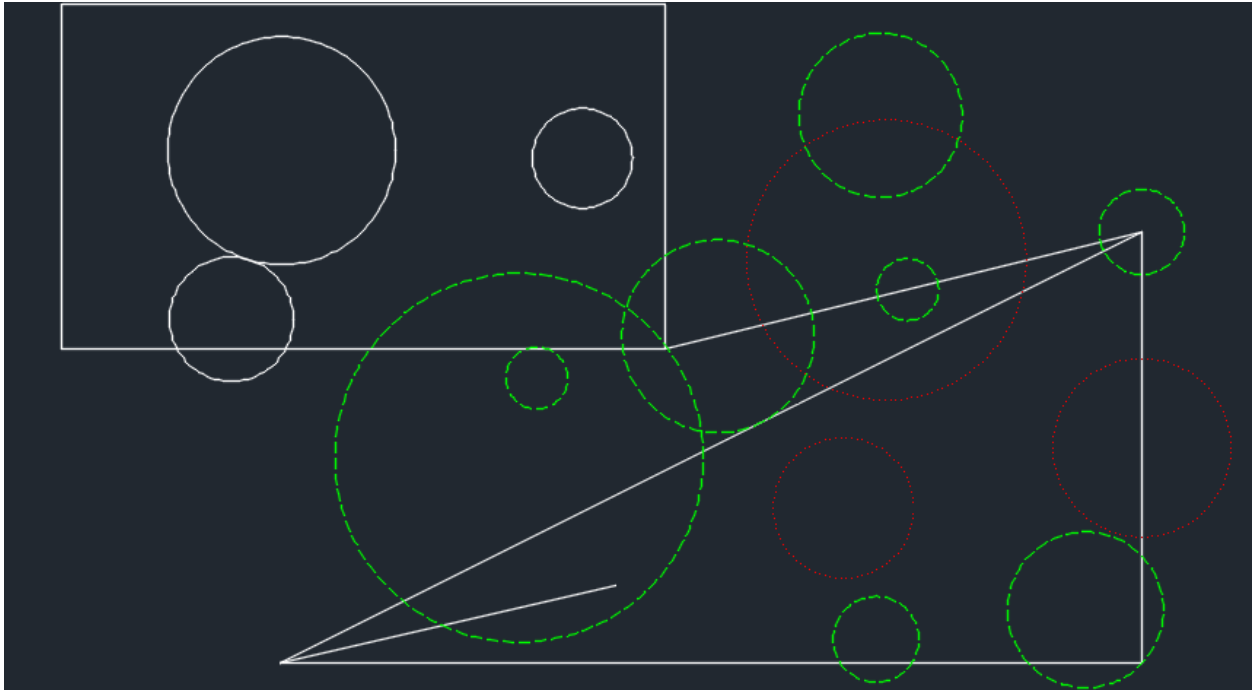

It is important to note that if we set object properties to somethng other than 'By Layer', the properties will remain even if we put them on a new layer.

Paper Space and Model Space

Model Space is used to draw the objects to their actual size, whereas Paper Space is used to scale the objects so they can be printed at a specific scale. So far our drawings have been done in model space. We can enter paper space by clicking the 'Model' button at the bottom of the screen or by clicking one of the Layout tabs at the bottom left of the screen. Below is what will be shown when you enter Paper Space:
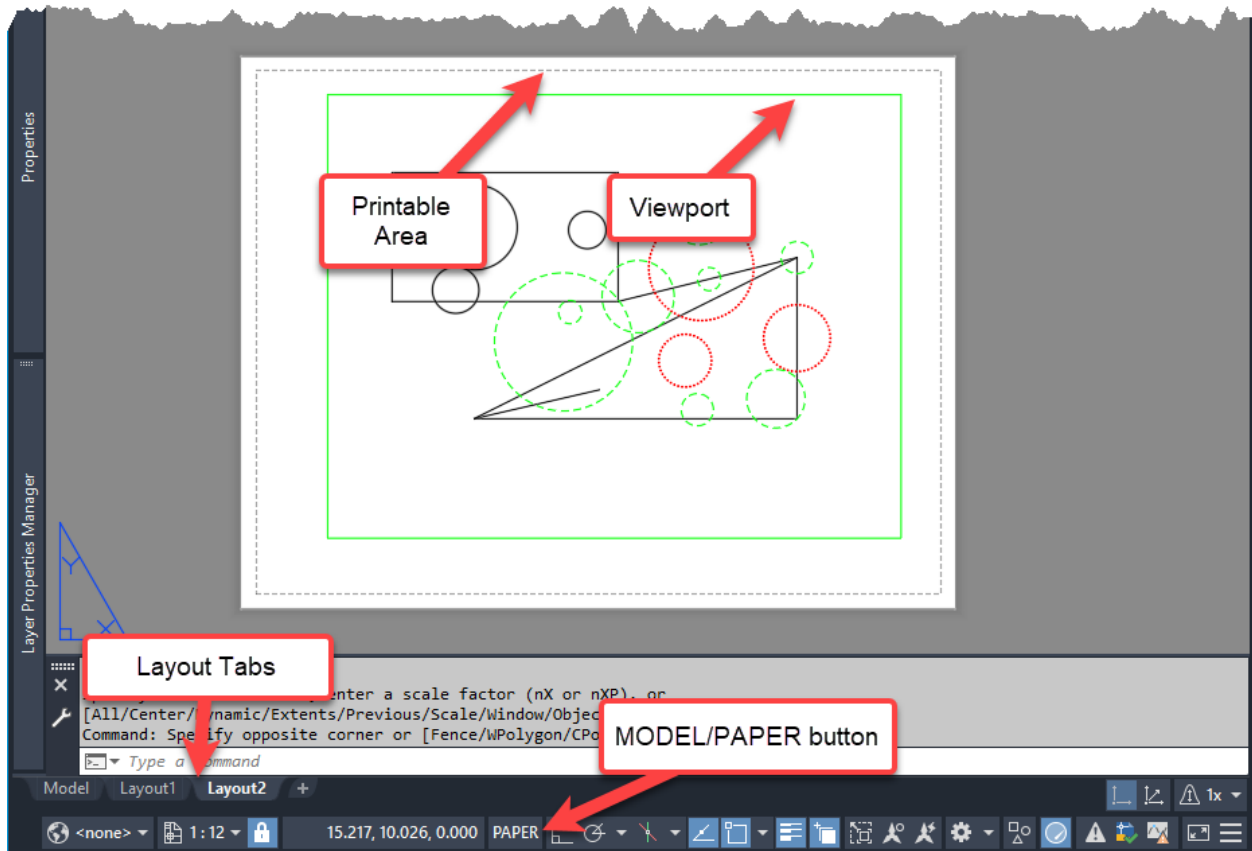
The white space shows the full paper size (this can be changed by right clicking on the Layout tab and selecting 'Page Setup Manager').

The Printable area shows the printing margins for the page. Anything outside this line may not show up when printed. This is controlled by the printer you select, so it is recommended that you modify your page setup prior to configuring your plot

The Viewport is similar to a "window" that looks into model space. You can double-click inside the viewport to make edits to the model. You can then double-click outside of the viewport to re-enter Paper Space.

While in Paper Space, you cannot edit objects in the model. You can, however, edit objects that have been drawn in Paper Space such as the viewport itself. Try using the viewport's grips to resize the viewport to the extents of the printable area. The results will be similar to what is shown below:
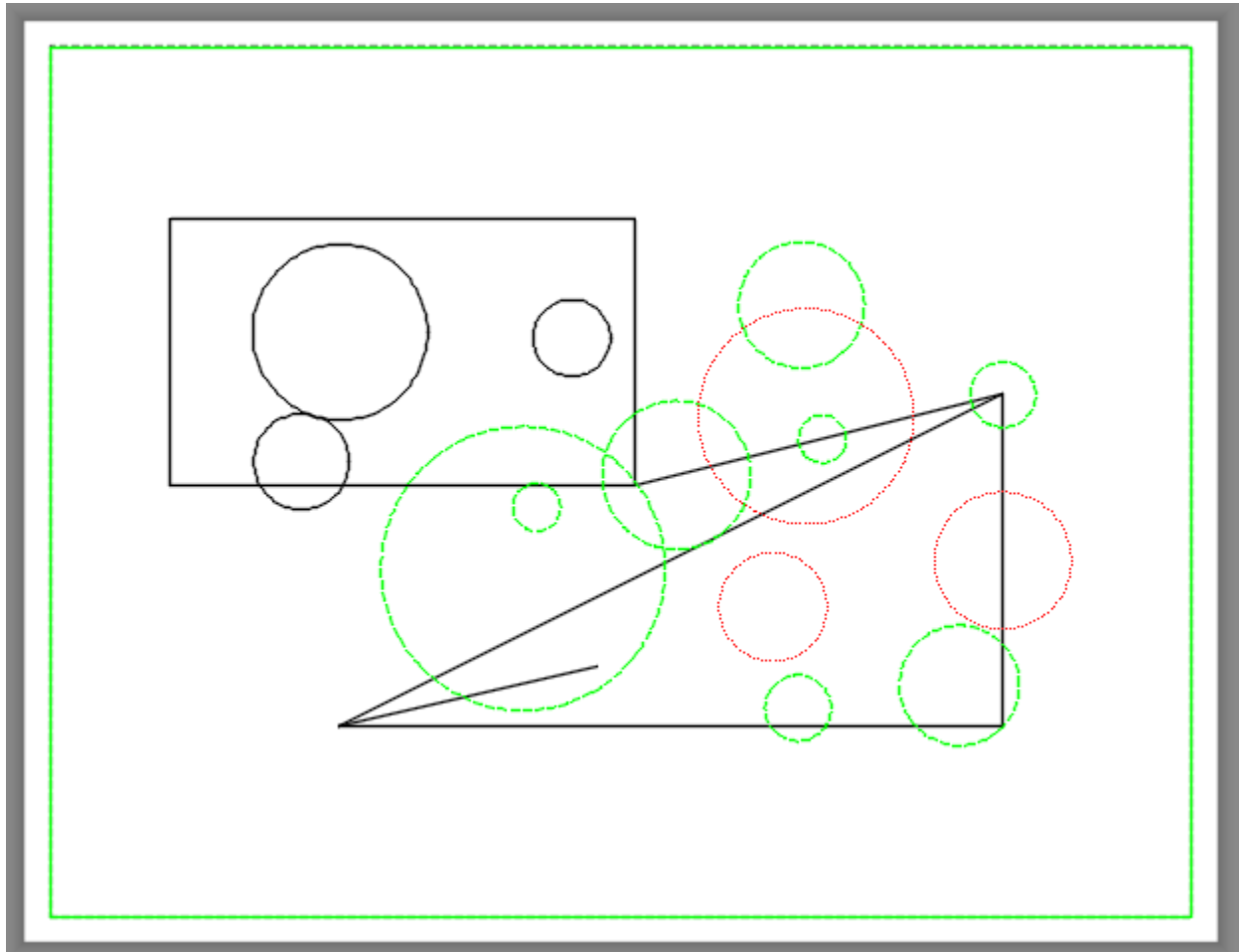
Perhaps the most important aspect of viewports are the scale of the model within them. Here we will set the scale of Model Space to a standard scale.

Setting the Scale within the Viewport

1) Double click inside the viewport to enter Model Space
2) Type 'Z' into the command line and press 'Enter'
3) Type '1/3xp' into the command line and press 'Enter'. This resizes Model Space so that if the drawing were printed, the scale would be 1" = 3'. If we had entered '1/5xp' the printed scale would be set to 1" = 5'.
4) Click the 'Model' button at the bottom of the page to re-enter Paper Space

Below is an example of how different scales will affect the appearance of the printed drawing.

1/3xp

1/5xp
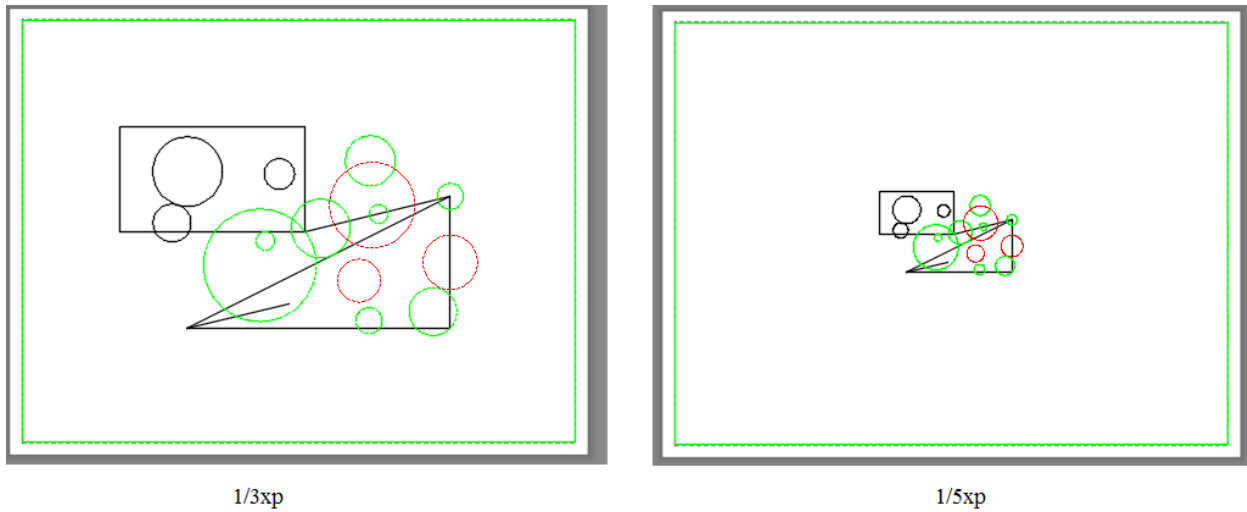
Sometimes we will want to print the drawing while excluding a certain set of layers. This can be easily done by freezing the layer altogether, but if our drawing has more than a couple of layers It can be troublesome to freeze and thaw the proper combination of layers every time we want to print. To prevent this issue, we can freeze layers in specified viewports.

Freezing Layers in Specific Viewports

1) Create the 'Lines', 'Rectangles', and 'Text' layers as shown below:
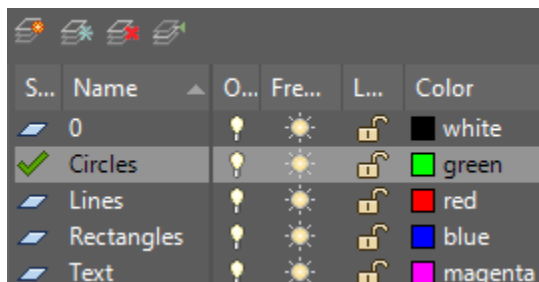
2) Enter Model Space and draw some lines on the 'Lines' layer, rectangles on the 'Rectangles' layer, and text on the 'Text' layer as shown below:

a. When prompted for a text height, choose a height of about 0.8
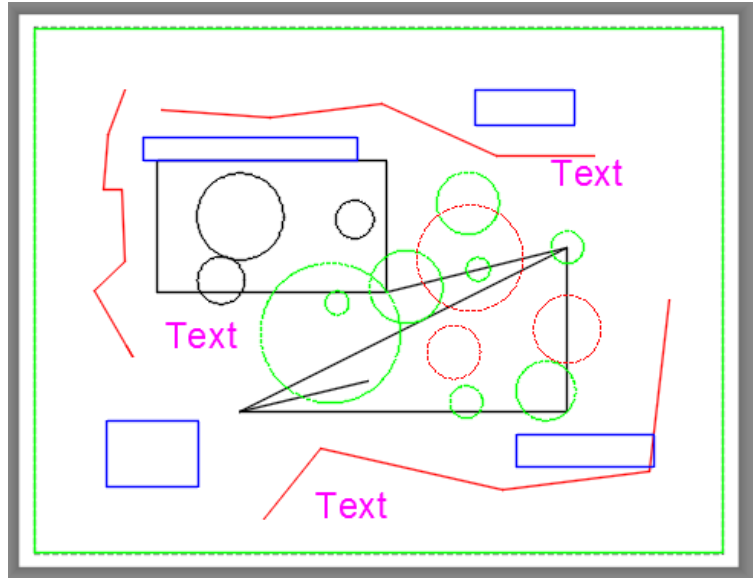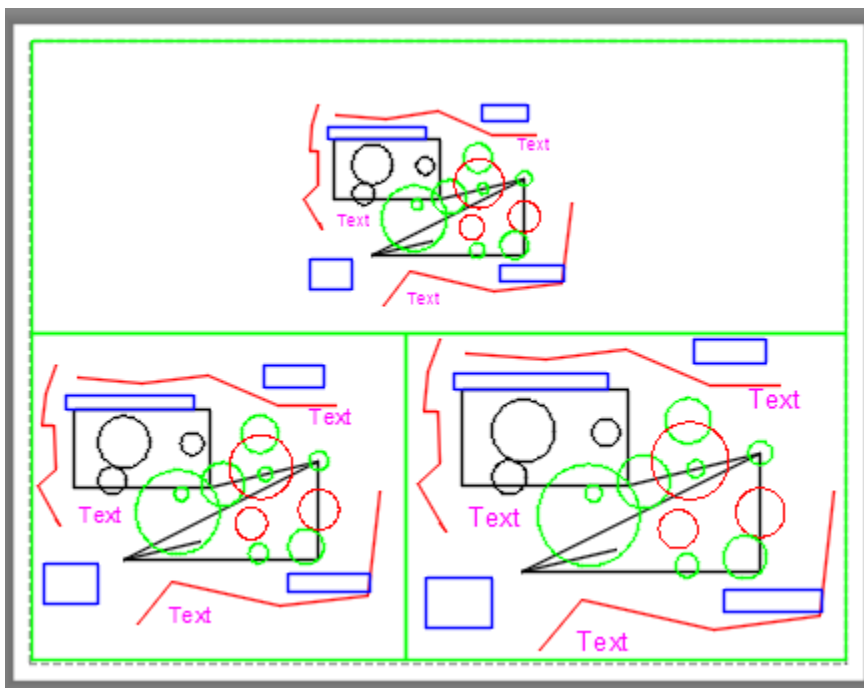

3) Resize the viewport to about half of the original size and scale the drawing so that all the objects are visible

4) Draw two more viewports by typing 'VPORT' into the command line and pressing 'Enter'. When the dialog box appears, click 'OK'. You can then draw the viewports as you would draw a rectangle. The results will be similar to what is shown below:

5) Double-click inside the top viewport to enter Model Space

6) In the 'Properties' toolbar, freeze the '0' layer in the current viewport by clicking the button shown below. Notice how this freezes the '0' layer in the top viewport, but not the other two viewports.

7) In the bottom left viewport, freeze the 'Text' and 'Lines' layers
8) In the bottom right viewport, freeze the 'Rectangles' and 'Circles' layers

The results will look similar to what is shown below:
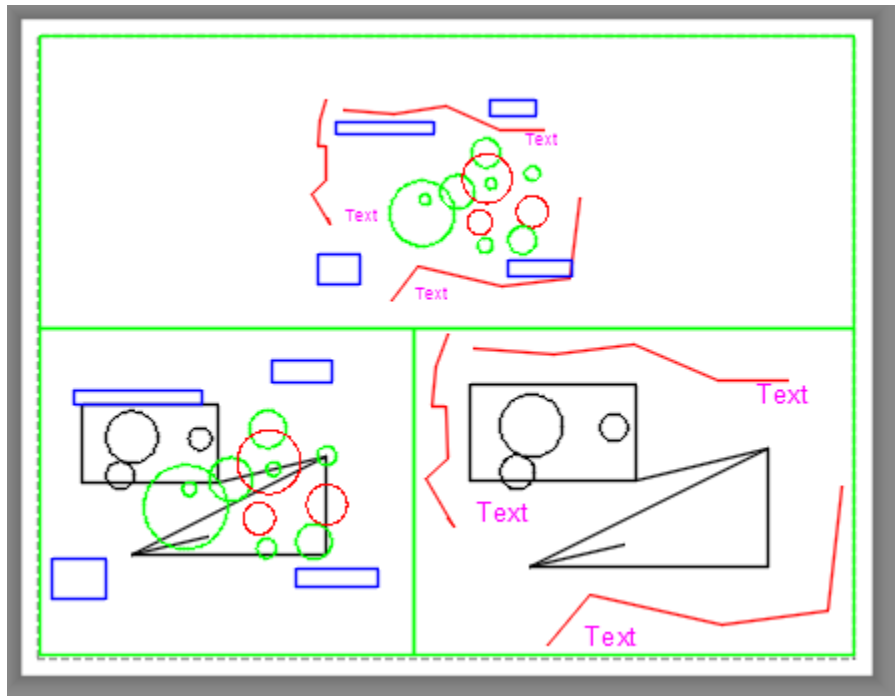
Commonly Used Toolbars, Commands, Etc.

Useful Toolbars

Standard	
Carlson Menus	
Properties	☐ ByLayer ▾ ——— ByLayer ▾ ——— ByLayer ▾ ByColor ▾
Layers (Carlson)	
Layers (AutoCAD)	💡☀🔲🔓🔲 0 ▾
Orbit	
Workspace	General ▾ ⚙ 🖳
Object Snap	
Draw	

Toolbars can be shown/hidden by right clicking in the toolbar area and selecting the toolbar of interest

Useful Commands

- Drafting
    - o 'PL' – draws a polyline
    - o 'L' – draws a line
    - o 'C' – draws a circle
    - o 'REC' – draws a rectangle
    - o 'A' – draws an arc
    - o 'H' – hatches a closed area
    - o 'TEXT' – inserts text
    - o
- Menu Related
    - o '-TOOLBAR' – allows you to specify a toolbar to open (useful if all toolbars are closed)
    - o 'RIBBON' – opens the ribbon
    - o 'RIBBONCLOSE' – closes the ribbon
    - o 'LAYER' – opens the layer properties manager
    - o 'PROP' – opens the properties menu

- General
    - o 'MOVE' – moves a selection of objects
    - o 'ROTATE' – rotates a selection of objects
    - o 'SCALE' – scales a selection of objects
    - o 'COPY' – copies a selection of objects (can also use Ctrl+C)
    - o 'CUT' – cuts a selection of objects
    - o 'PASTE' – pastes what was previously copied or cut (Can also use Ctrl+V) 'E' – erases a selection of objects (can also select objects and press 'Delete')
    - o 'REDO' – repeats an action (can also use Ctrl+Y)
    - o 'U' – undoes an action (can also use Ctrl+Z)
    - o 'Z' – specifies the zoom of the drawing
    - o 'REGEN' – 'resets' the drawing so you can zoom farther in or out
- Editing
    - o 'VPORT' – draws a viewport in layout space
    - o 'UNITS' – changes the drawing units
    - o 'TR' – trims an object
    - o 'BLOCK' – turns entities into a block
    - o 'JOIN' – joins objects into one entity
    - o 'X' – explodes an object into individual components

Full list of quick keys found under Settings Pulldown -> Quick Keys; Note that these can be customized

Useful Mouse/Keyboard Actions
- Left click – select an object or a set of objects
- Shift + Left click – deselects an object or set of objects
- Right click – pulls up options
- Scroll forward/up – zooms in
- Scroll backward/down – zooms out
- Click scroll wheel – pans the view
- Double click scroll wheel – zoom extents
- Spacebar – works similar to Enter key in many cases
- Delete – deletes selected objects
- Ctrl + N – opens a new drawing