A Practical Guide to Parametric Drawing in AutoCAD

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Parametric design tools aren't just for programs like Inventor software, Revit software, or AutoCAD Civil 3D software; there is also a set of parametric drawing tools that you can use to create dynamic relationships and constraints between objects in AutoCAD software. The parametric drawing tools will revolutionize the way that you draw and edit objects in AutoCAD software. This class will introduce you to parametric drawing in AutoCAD software by using both geometric and dimensional constraints to add intelligence to your objects. You will learn how using Auto Constrain and Inferred Constraints can help you quickly add constraints and change your process from drafting to modeling. If you've ever wanted geometry in your drawing to update based on changes that you've made to other objects, or if you've wanted to type a new value into a dimension and have the object update based on this new value, this class is for you.

Learning Objectives
At the end of this class, you will be able to:

1. Learn how to create geometric relationships between objects by adding constraints

2. Learn how to define dimensional constraints

3. Learn how to identity and edit constrained objects

4. Learn how to use inferred constraints to have AutoCAD automatically define constraints for you

Your AU Experts

Rick Ellis is the President of CADapult Software Solutions, Inc., where he provides training and consulting services to clients around the country, helping them get the most out of their design software investment. Rick specializes in AutoCAD® Civil 3D®, AutoCAD® Map 3D, Autodesk® InfraWorks™, AutoCAD® Raster Design, and AutoCAD®. He is a member of the Autodesk Developer Network, and author of several critically acclaimed books on AutoCAD Civil 3D, and AutoCAD Map 3D; including the Practical Guide series. Rick continues to use AutoCAD Civil 3D on projects in a production environment, in addition to teaching classes to organizations both large and small around the country. This practical background and approach has made him a sought after instructor by organizations around the world.

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Overview

What is parametric drawing?

The Autodesk Definition: "Feature in AutoCAD that assigns constraints to objects, establishing the distance, location, and orientation of objects with respect to other objects."

If the definition above didn't answer all of your questions about parametric drawing, I'll expand on that and go into a bit more detail. AutoCAD 2010 introduced Parametric drawing. This is not only a relatively new feature for AutoCAD, it is a new concept that will change the way that you create and edit drawings in AutoCAD. While this is a somewhat new feature for AutoCAD, similar tools for parametric design have been in other products like Inventor, Revit, and Civil 3D for some time and you may be familiar with them. Put simply, the idea of parametric drawing is that objects can be related to each other. For example, if you want two lines to be parallel, they would always be parallel. If you change one line then the other will update to match it. This is just one example. However, if you think about all the possibilities, and all the time that you have spent editing drawings to make sure that all the necessary and related changes have been made for a simple change to the design, these tools have the potential to revolutionize the way that you work.

AutoCAD uses two types of Parametric Constraints:

- Geometric Constraints

    - The Autodesk Definition: "Rules that define the geometric relationships of objects (or points of objects) elements and control how an object can change shape or size. Geometric constraints are coincident, collinear, concentric, equal, fix, horizontal, parallel, perpendicular, tangent, and vertical."

    - Sticky Object Snaps. They maintain the geometric relationship between objects rather than setting it once at the time you use the object snap and then allowing it to change in the future.

    - Add intelligence to your drawings.

    - Allow you to think more about modeling and less about drafting.

- Dimensional Constraints

    - The Autodesk Definition: "Parametric dimensions that control the size, angle, or position of geometry relative to the drawing or other objects. When dimensions are changed, the object resizes."

    - You can type the value into a dimension and the object updates. It's the opposite of associative dimensions. With Dimensional Constraints the dimension value drives the geometry rather than the geometry driving the dimension.

    - Can include equations.

    - Can even reference other objects. For example, line 1 is twice the length of line 2.

Exercise 1 – Working with Existing Constraints

1. Open the drawing **Widget Assembly complete.dwg** from the folder called *Completed Assembly* in the dataset.
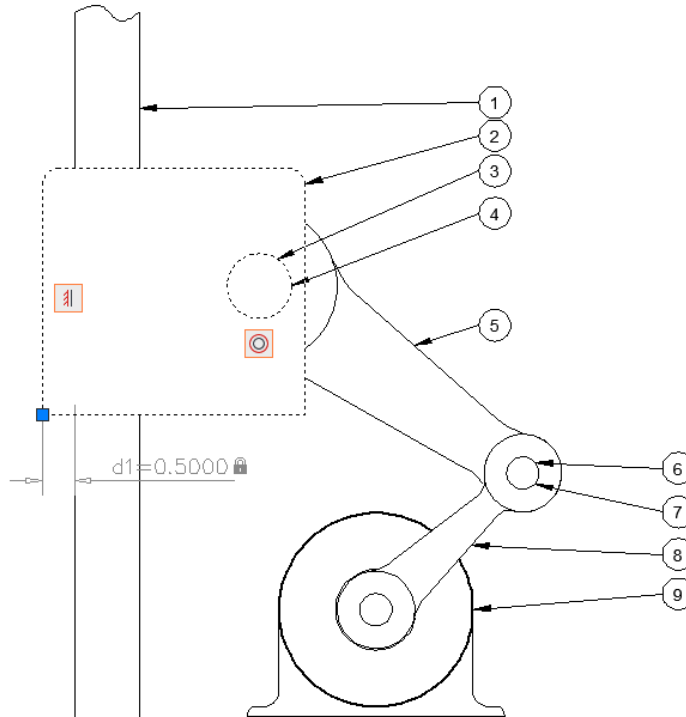

2. Select the block representing the slider on the shaft (identified by callout number 2).

3. Move the block.

4. Notice the block can only move along the shaft and the arm rotates as it moves.

5. Double click the dimension d1 and change the value to 1.5

6. Notice that changing the value of the dimension moves the block.

7. Select and move one of the callouts.

8. Notice the entire row of callouts moves together.

9. Try moving other pieces of this assembly to see the different constraints in action.

10. Open the drawing **Parametric - geometric.dwg** from the dataset.

11. Move and stretch different pieces of the orthographic projection to see how constraints have been set up within it.

Geometric Constraints

Geometric Constraints maintain the geometric relationship between objects based on basic geometric properties of the entity or entities you apply them to. AutoCAD supports the following geometric constraint types:

- Coincident

- Co-linear

- Tangent

- Perpendicular

- Parallel

- Horizontal (relative to the current UCS X axis)

- Vertical (relative to the current UCS Y axis)

- Concentric

- Equal

- Symmetric

- Smooth

- Fixed

The commands to create and manage Geometric Constraints can be found on the Parametric tab of the ribbon.
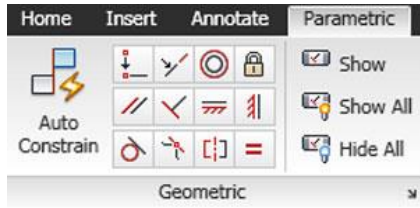
The table below shows the types of objects that can be used to create geometric constraints and their constraint points.

Objects	Constraint Points
Line	Endpoints, Midpoint
Arc	Center, Endpoints, Midpoint
Spline	Endpoints
Ellipse, Circle	Center
Polyline	Endpoints, midpoints of line and arc, center of arc
Block, Xref, Text, Mtext, Attribute, Table	Insertion point

Tips when creating geometric constraints:

- When applying constraints between two entities AutoCAD modifies the second entity selected, leaving the first entity unmodified.

- If you convert an object that has constraints to a ployline the constraints are lost.

- If you explode a polyline that has constraints the constraints are lost.

- If you copy an object with constraints the constraints are copied if all the objects involved in the constraint are copied.

Constraint Bars

Constraint Bars provide a heads-up interface to help you manage geometric constraints in your drawings. Constraint Bars look and behave a lot like transparent floating tool bars, except that each button on a bar represents a single geometric constraint.

When you place your cursor over individual constraints on a constraint bar AutoCAD highlights the button, the entity the constraint applies to, and the corresponding button and entity participating in the constraint.
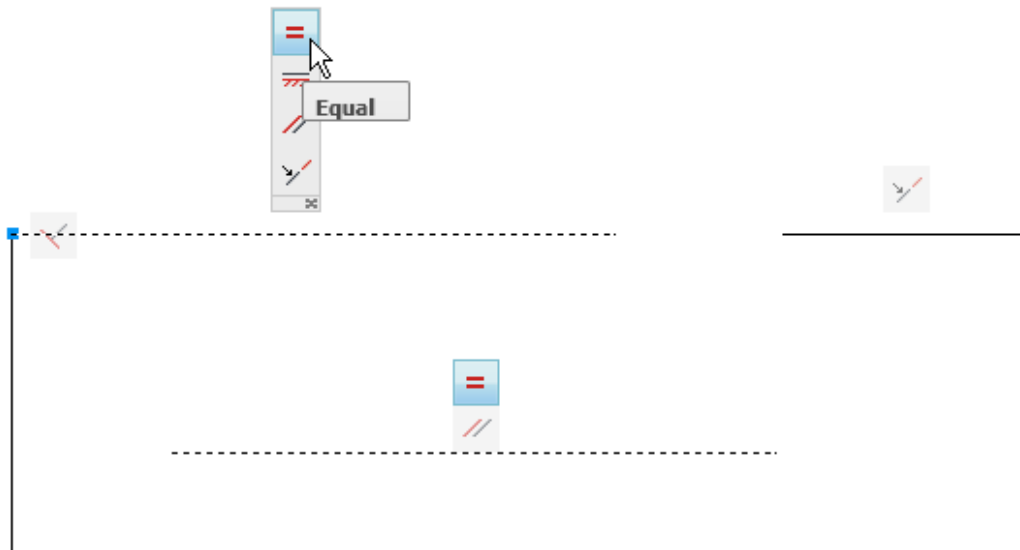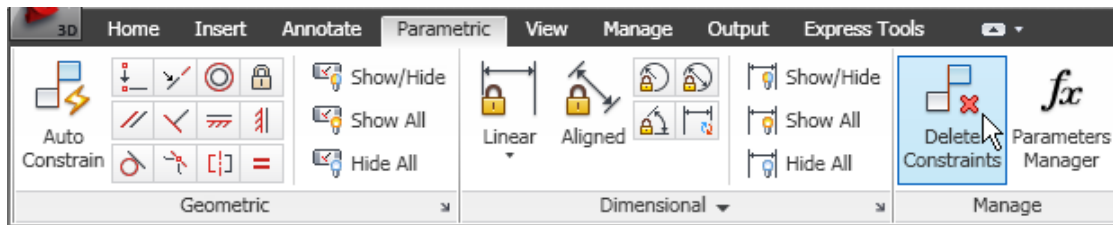
When you right-click on a constraint on the constraint bar there are several commands which you can perform on the constraint, including deleting the constraint, hiding the bar, or managing the constraint bar settings.
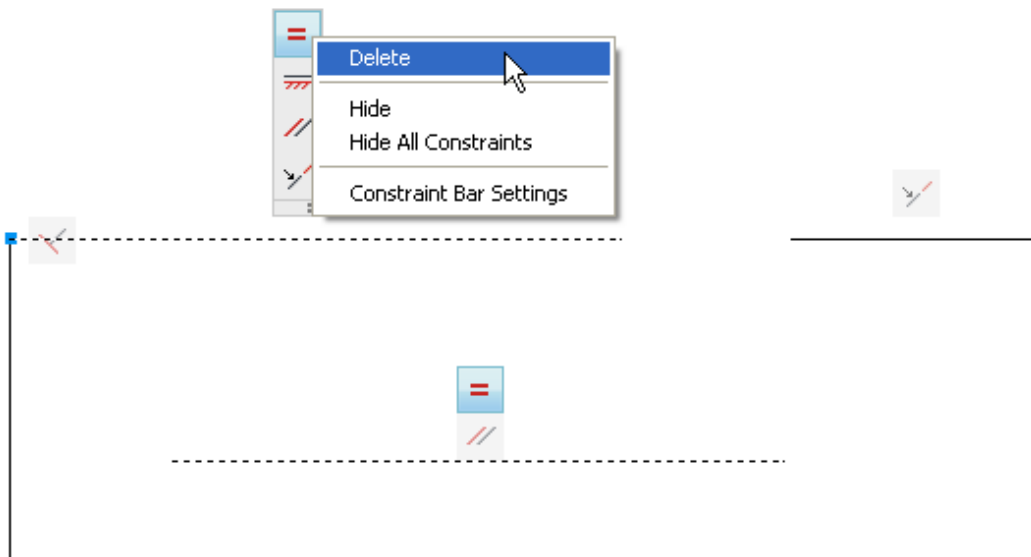
To delete all constraints on an entity use the Delete Constraints command.

Ribbon: Parametric tab >> Manage panel >> Delete Constraints.


Exercise 2 – Working with Geometric Constraints

1. Open the drawing **Parametric - geometric.dwg** from the dataset.

2. Pan to a blank area of the drawing.

3. Draw 4 individual lines similar to the graphic below.
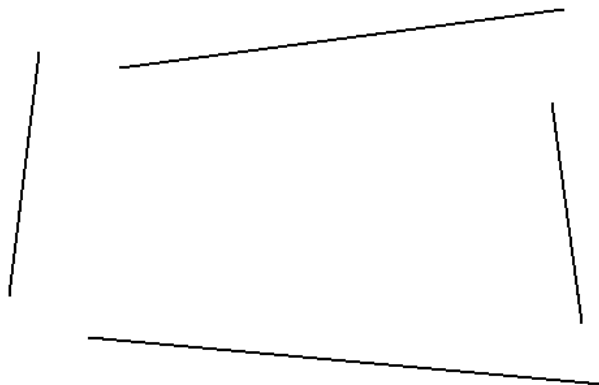
4. Add Geometric Constraints to make this a dynamic rectangle.

    a. Use the Coincident, Parallel, and Perpendicular constraints.

5. Zoom extents to find the bracket in the drawing as displayed below.
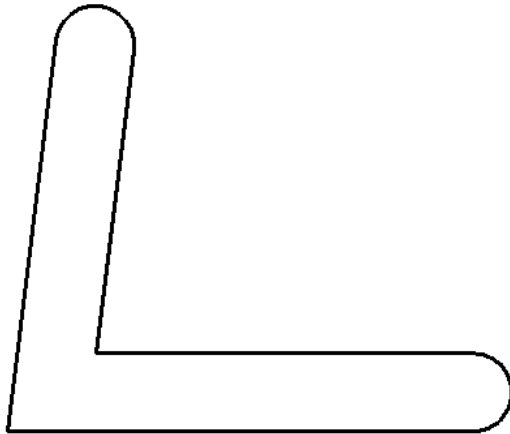
6. Add Geometric Constraints to make the bracket hinge at the corner while keeping both sides of the part the same size.

7. Zoom extents to find the orthographic projection.

8. Copy the orthographic projection.

9. Remove all the constraints from the orthographic projection.

10. Add geometric constraints to the orthographic projection to make it behave as the original.

Auto Constrain

If applying geometric constraints one at a times seems like a tedious task there is an option to let AutoCAD look for objects that can be constrained and add them for you. Auto Constrain examines entities you select and attempts to automatically constrain the geometry based on its current position.

You can control the settings for the Auto Constrain command in the Constraint Settings dialog box.

Ribbon: Parametric tab >> Geometric panel >> ⌐ >> Constraint Settings.
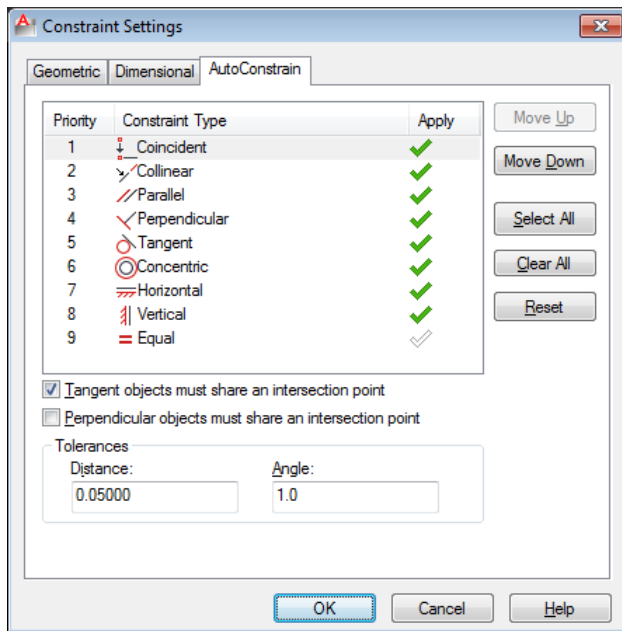
Here you can select the type(s) of constraints that you want the Auto Constrain command to apply. You can also set Tolerances for distance and angle. These tolerances will determine if constraints are applied and objects are modified when they are "close" to geometrically accurate. When used properly this can help clean up a drawing that was created without using object snaps. However, you want to choose your tolerances carefully as it will allow the Auto Constrain command to modify geometry. If you only want the Auto Constrain command to apply constraints where the geometry is perfect and not modify any geometry, set the tolerances to 0.
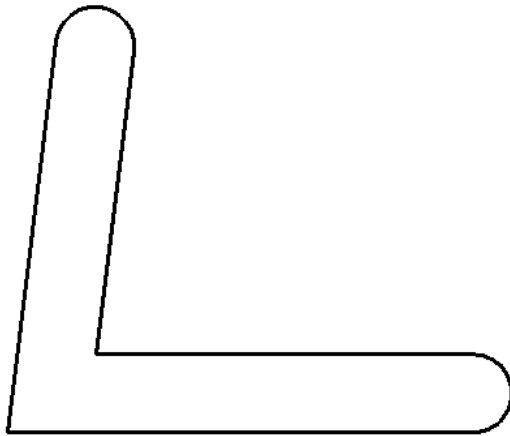
Inferred Constraints

Inferred constraints automatically apply geometric constraints while creating and editing geometric objects, removing the need for you to add constraints later. The Infer Constraints mode works with your object snaps and is enabled with a toggle on the status bar. ⊹
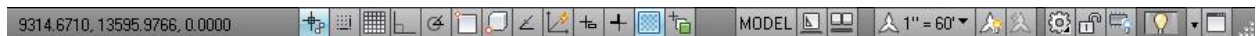
Once enabled object snaps that are used when creating or editing objects are also used to infer geometric constraints. Objects are not modified by inferred constraints.

Exercise 3 – Working with Auto Constrain and Inferred Constraints

1. Open the drawing **Parametric – Inferred.dwg** from the dataset.

2. Pan to a blank area of the drawing.

3. Draw a rectangle using the **rectangle** command.

4. Use the **Auto Constrain** command to add constraints.

5. Notice what constraints are added.

6. Zoom extents to find the bracket in the drawing as displayed below.

7. Use the **Auto Constrain** command to add constraints.

8. Notice what constraints are added.

9. Turn on **Inferred constraints**.

10. Draw a rectangle using the **rectangle** command.

11. Notice what constraints are added.

Dimensional Constraints

Dimensional Constraints constrain objects by allowing you to enter values or formulas. They work similar to associative dimensions, just in reverse. While associative dimensions update the value of the dimension as the object changes, dimensional constraints update the object when the value of the dimension changes. The dimensions drive the geometry rather than the geometry driving the dimensions.

Dimensional constraints come in the following types:

- Aligned

- Horizontal

- Vertical

- Radial

- Diameter

- Angular

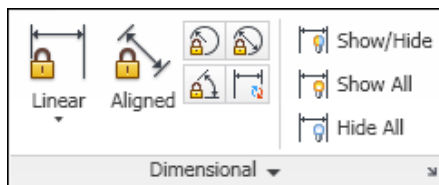Dimensional constraints can constrain the following properties:

- Distances between objects, or between points on objects

- Angles between objects, or between points on objects

- Sizes of arcs and circles

There two different kinds of dimensional constraints:

- ▪ Dynamic

  - • Maintain the same size regardless of zoom level

  - • Can easily be turned on or off globally in the drawing

  - • Display using a fixed, predefined dimension style

  - • Position the textual information automatically, and provide triangle grips with which you can change the value of a dimensional constraint

  - • Do not display when the drawing is plotted

- ▪ Annotational

  - • Change their size when zooming in or out

  - • Display individually with layers

  - • Display using the current dimension style

  - • Provide grip capabilities that are similar to those on dimensions

  - • Display when the drawing is plotted

If you need to control the dimension style of dynamic constraints, or if you need to plot dimensional constraints, use the Properties palette to change dynamic constraints to annotational constraints.

The commands to create and manage Dimensional Constraints can be found on the Parametric tab of the ribbon.

Tips when creating dimensional constraints:

- When applying dimensional constraints AutoCAD modifies the constrained geometry to satisfy the new constraint.

- If you convert an object that has constraints to a ployline the constraints are lost.

- If you explode a polyline that has constraints the constraints are lost.

- If you copy an object with dimensional constraints the constraints are copied.

- Dimensional constraints can contain equations.
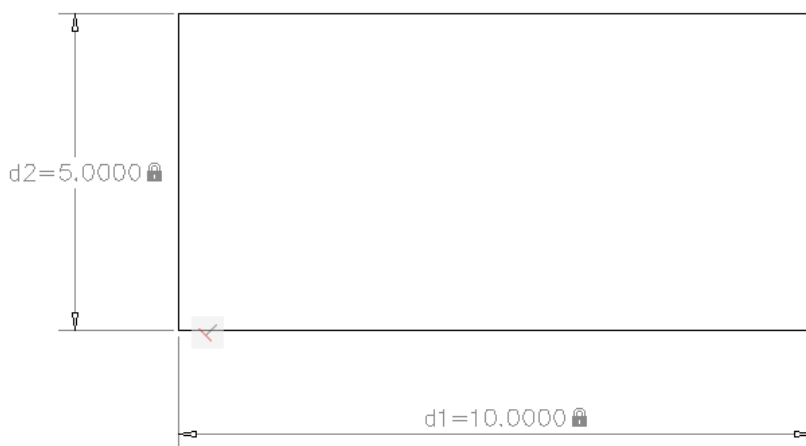
The example above contains a rectangle with two basic dimensional constraints.
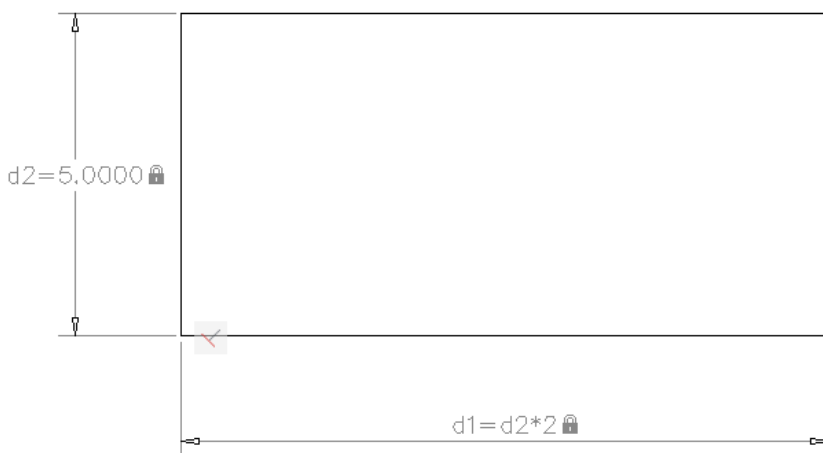
The example above contains a rectangle with two dimensional constraints where the length (d1) is equal to twice the height (d2).

You can manage all the values of your dimensional constraints with the Parameters Manager.

Ribbon: Parametric tab >> Manage panel >> Parameters Manager.
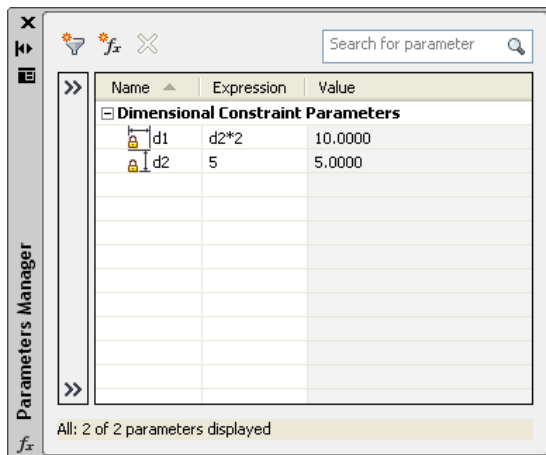

In the Parameters Manager you can edit expressions and even add user defined variables that you can use in expressions.

Exercise 4 – Working with Dimensional Constraints

1. Open the drawing **Parametric - dimensions.dwg** from the dataset.

2. Zoom to the rectangle.

    a. It already has geometric constraints.

3. Add Dimensional Constraints for the width and length.

4. Edit the width to be 3.

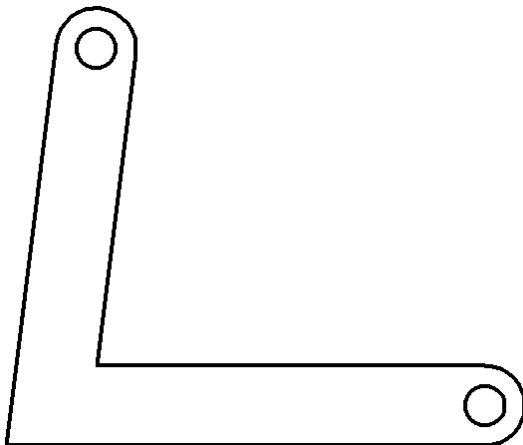5. Edit the length to be twice the width by editing the expression.

6. Zoom extents to find the bracket in the drawing as displayed below.

    a. It already has geometric constraints.
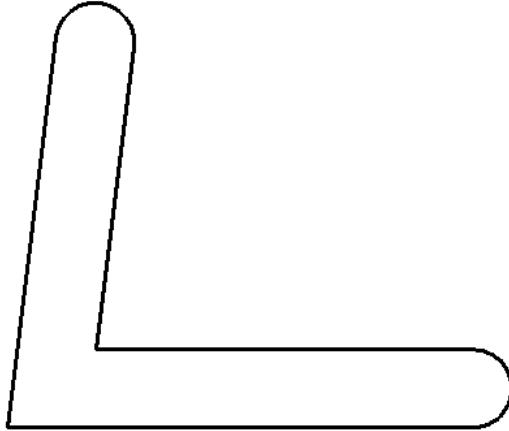
7. Add a dimensional constraint to control the angle.

8. Draw circles at each end of the part.

9. Use a concentric geometric constraint to position them

10. Add a dimensional constraint that makes them half the outer radius of the part.

Constraints in Dynamic Blocks

Introduced in AutoCAD 2005, Dynamic Blocks extend the capabilities of traditional blocks by providing the ability to define custom grips and properties for your blocks which affect the geometry for the block. You create dynamic blocks by combining Block Actions and Block Action Parameters within the block definition. Now you can extend the power of blocks even further by adding geometric and dimensional constraints to your dynamic blocks.

When you add geometric and dimensional constraints to dynamic blocks it is best to add them in the block editor using the commands on the Block Editor tab of the Ribbon.

A Block Properties table allows you to define and control values for parameters and properties within a block definition. This will become the list of selectable values in the dynamic block.

Exercise 5 – Working Constraints in Dynamic Blocks

1. Open the drawing **Parametric - blocks.dwg** from the dataset.

2. Open the block editor.

   a. **Ribbon:** Insert tab >> Block panel >> Block Editor.

   b. Name the new block **AUParametric**.
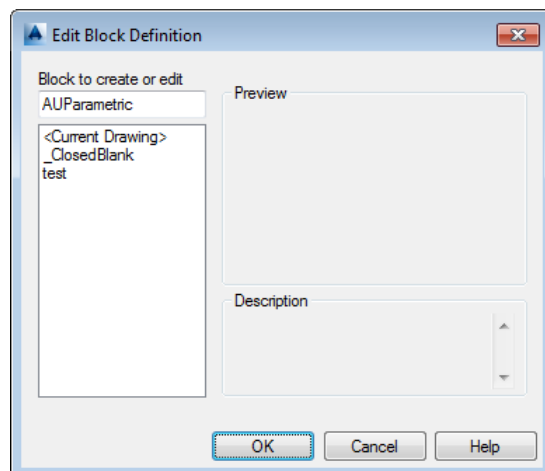
3. Draw a rectangle using the **rectangle** command starting the lower left corner of the rectangle at 0,0.

4. Add Geometric Constraints to make this a dynamic rectangle.

5. Add Dimensional Constraints for the width and length.

6. Edit the width to be 5.

7. Edit the length to be twice the width by editing the expression.
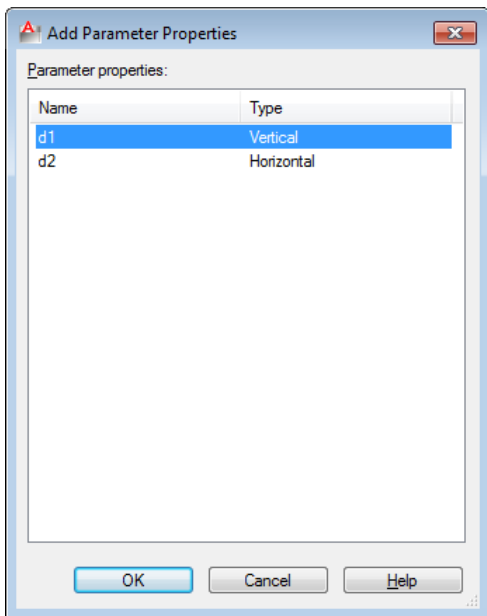
8. Add a Block Table.
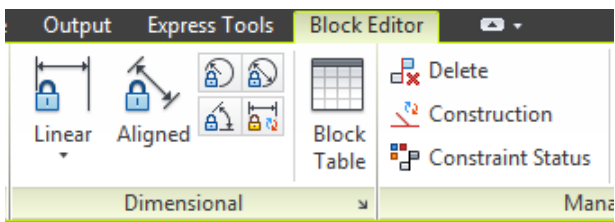
    a. Place the block table near the origin of the block.

    b. Placement of the block table does not need to be exact. It will be the location of a grip on the block that can be used to select standard sizes.
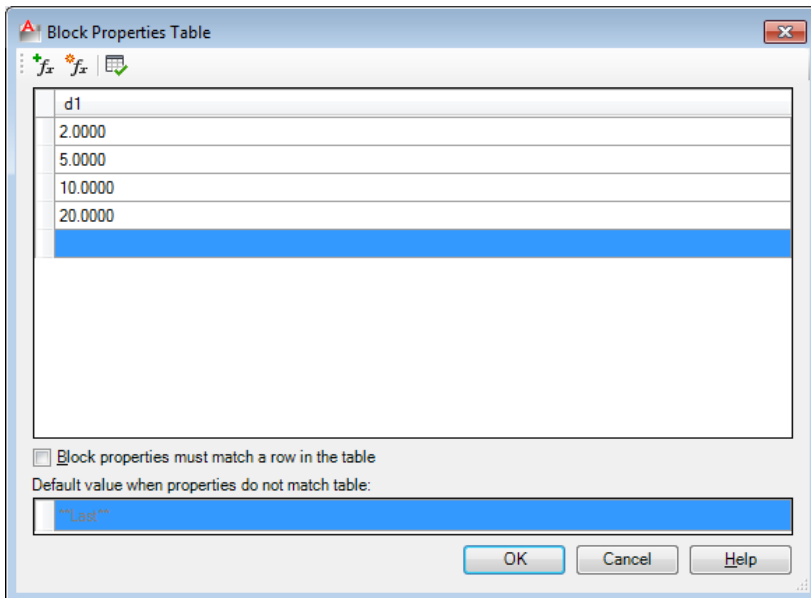
9. Enter 1 for the number of grips.
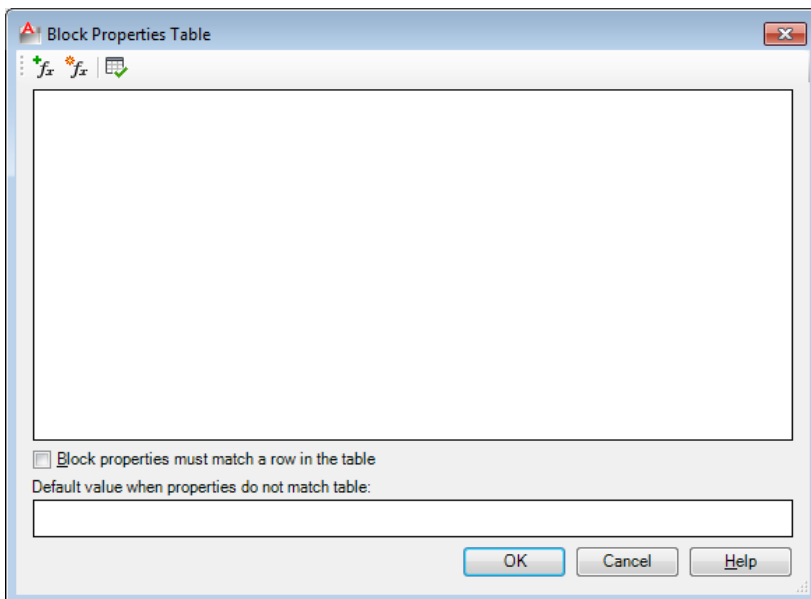
10. Click the Add Properties button

11. Select the d1 parameter and Click **<<OK>>**.



12. Enter values for d1 as shown above.

13. Click <<OK>> when finished.

14. Close the block editor and save the changes.

15. Insert the block anywhere in your drawing.

16. Select the block and notice the available grips.

a.   You will be able to stretch it in the vertical direction and the rectangle will keep the 2:1 ratio of length to width.

b.   Select the block table grip and you will see the predefined widths.
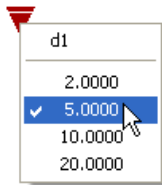
c.   Select one of the values and notice how the block resizes.

Conclusion

Parametric drawing in AutoCAD with geometric and dimensional constraints is a powerful set of tools that may drastically change the way that you create and edit drawings. I hope that this introduction to these exciting features has got you thinking about ways that you can apply it to your own drawings and projects. I encourage you to try it out, start small at first, but I am confident that you fill not only find these tools a powerful time saver but also intuitive and easy to learn.