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Design with Parametric Constraints in AutoCAD 2010

This tutorial consists of four 10-15 minute lessons that will provide you with a basic understanding of parametric drawing, familiarize you with geometric and dimensional constraints, and introduce you to controlling a design with formulas and parameters.

Audience: Users new to the Parametric Drawing feature in AutoCAD 2010

Prerequisites: Basic AutoCAD knowledge

Time to complete: 40-50 minutes

Objectives

In this tutorial, you learn the basics of Parametric Drawing including the following:

- Work with Geometric Constraints
- Work with Dimensional Constraints
- Control a Design Using Parameters and Expressions

Tutorial Files

All necessary files for this tutorial are located at <http://www.autodesk.com/autocad-tutorials>.

Recommended: Before starting this tutorial

- 1 Download the *parametric_drawing.zip* file from <http://www.autodesk.com/autocad-tutorials>.
- 2 Unzip *parametric_drawing.zip* to *C:\My Documents\Tutorials*.

In this Tutorial

- Lesson 1: Introduction to Parametric Drawing
- Lesson 2: Work with Geometric Constraints
- Lesson 3: Work with Dimensional Constraints
- Lesson 4: Control a Design Using Parameters and Expressions

Lesson 1: Introduction to Parametric Drawing

Time to complete: 10-15 minutes

Learning Objectives

On completing this lesson, you will be able to do the following:

- Describe the purpose of parametric drawing.
- Recognize geometric constraints, dimensional constraints, and the constraint cursor icon.
- Identify the objects that are constrained and what constraints apply to each object.
- Turn on and off the display of geometric and dimensional constraints, and control the precision and unit style of dimensional constraints.

File Name: *PD_Deck1.dwg*

Command: *CONSTRAINTBAR, DYNCONSTRAINTDISPLAY*

Parametric drawing is a method for designing with constraints. *Constraints* are rules that are applied to 2D geometry. By applying constraints, you can control the location, size, distance, angle, and other parameters of objects in a drawing. As a result, you can identify and maintain specifications in a project.

There are two types of constraints:

- *Geometric constraints* control the relationships of objects with respect to each other.
- *Dimensional constraints* control the distance, length, angle, and radial values of objects.

Let's explore these constraints by taking a tour of a constrained drawing of a backyard deck plan.

To view a constrained drawing

You take a tour of a constrained drawing of a simple backyard deck.

- 1 Start AutoCAD and then on the ribbon, click the Parametric tab.



- 2 On the Dimensional panel, click Show Dynamic Constraints to make sure that they are turned off. On the Command line, you should see the following:

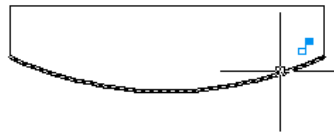
Enter new value for DYNCONSTRAINTDISPLAY <1>: 0

- 3 Open the drawing file, *PD_Deck1.dwg*. It should be located in the *C:\My Documents\Tutorials* folder.



This is the plan view of the deck. However, this drawing could represent a mechanical part or a section of a wide gutter instead, depending on your discipline.

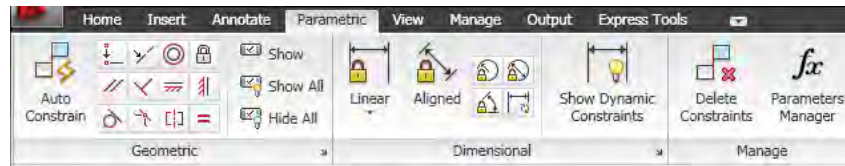
- 4 Move your cursor over the objects in the drawing. Notice the small, blue cursor icon. It indicates that each object has one or more constraints applied to it.



To view geometric constraints

The display of all constraints has been turned off. Let's turn on the display of geometric constraints to see what they look like.

- 1 On the Geometric panel, click Show All. 

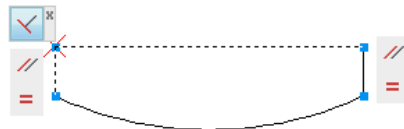


- 2 Click and drag the constraint icons to relocate them as shown.



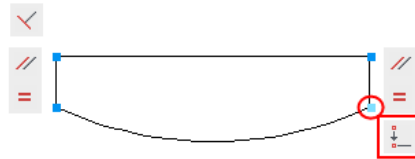
All the geometric constraints are now displayed. Later, you will learn how to create and delete them.

- 3 Move your cursor over each constraint icon and notice the tooltip that describes it.
- 4 Continue moving your cursor over each constraint icon and notice that the associated objects are highlighted so you can determine which objects are constrained.



The two vertical lines are constrained to be parallel and equal in length. The left vertical line is constrained to be perpendicular to the horizontal line.

- 5 Move your cursor over each object and notice that the geometric constraints associated with it are highlighted.
- 6 Move your cursor over each blue square on the corners of the deck to display the Coincident constraint icon.



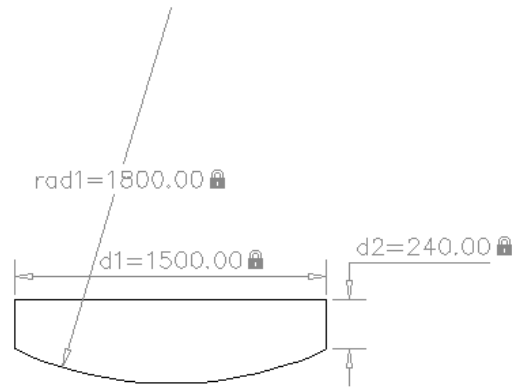
Coincident constraints display as blue squares to reduce clutter. They constrain the endpoints of the lines and the arc to remain in contact.

- 7 On the Geometric panel, click Hide All to turn off the display of the geometric constraints.

To view dynamic constraints

Let's turn on the dimensional constraints to see what they look like.

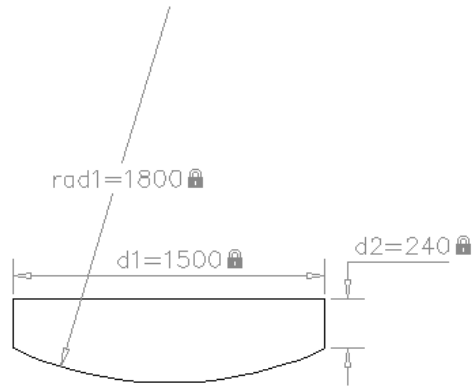
- 1 On the Dimensional panel, click Show Dynamic Constraints.
Dynamic constraints are the most common type of dimensional constraints used. The other type, called *annotational constraints*, are used for plotting and you will learn about them later.
This deck was constructed using metric units (centimeters).



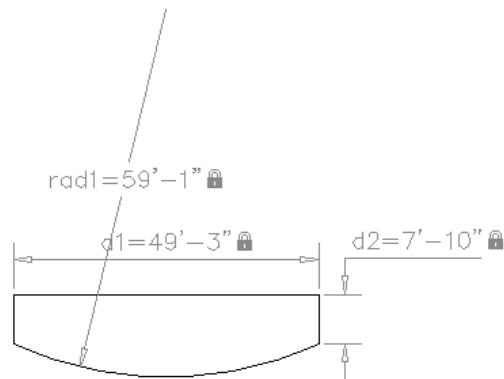
Dynamic constraints look like dimensions, but behave in the opposite way. Dimensions are driven by objects—they *report* the lengths, angles, and radial sizes of objects. In contrast, dynamic constraints drive objects—they *determine* the lengths, angles, and radial sizes of objects.

The default format of dynamic constraints includes a name such as *d1* or *rad1*, and a lock icon. Later, you will learn how to change the values of these constraints to control the size and shape of a design.

- 2 Zoom in and out of the drawing. Notice that the dynamic constraints always remain the same size.
You can change the numeric display style of dynamic constraints by changing the units or the display precision.
- 3 At the Command prompt, enter **units**.
- 4 In the Drawing Units dialog box, under Length, change the linear precision from 0.00 to 0 and click Ok.



- 5 If you use architectural units, open the drawing file, *PD_deck1_imperial.dwg*. Then use the UNITS command to change the unit style to Architectural with a precision of 0'-0".



To view the effects of constrained objects

- 1 Click Show All to turn on the display of geometric constraints.
- 2 Start the Move command and select the horizontal line. Move it to a different location.
Because the deck is *fully constrained*, all the objects are dependent on each other, and the shape and size of the deck does not change.
- 3 Close the drawing without saving it.

Summary

Parametric drawing has many applications for disciplines that require applying and maintaining design specifications. Geometric and dimensional constraints work together to include the design intent and requirements within a drawing. In the following lessons, you learn how to apply and work with constraints.

Review Questions

- 1 How would you describe the purpose of parametric drawing and constraints to someone?
- 2 What is the purpose of the blue icon that appears when you roll over some objects?
- 3 How can you tell which geometric constraints are applied to a specific object?
- 4 What is the purpose of dimensional constraints?
- 5 How can you change the precision displayed in dimensional constraints?

Lesson 2: Work with Geometric Constraints

Time to complete: 10-15 minutes

Learning Objectives

On completing this lesson, you will be able to do the following:

- Create coincident, perpendicular, and parallel constraints.
- Recognize and use the point glyph when creating constraints.
- Use the Autoconstrain feature to apply all geometric constraints automatically.
- Delete or relax one or all the constraints applied to an object.

File Name: *PD_Deck2.dwg*

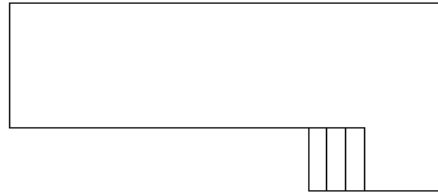
Command: *GEOMCONSTRAINT, AUTOCONSTRAIN*

Geometric constraints are applied before dimensional constraints to define and preserve the general shape of the design. For example, geometric constraints can specify that two endpoints always remain coincident, or that specified lines always remain perpendicular. AutoCAD 2010 supports 12 types of geometric constraints.

Let's apply geometric constraints to a drawing of another simple backyard deck plan.

To apply coincident constraints

- 1 Open the drawing file, PD_Deck2.dwg.



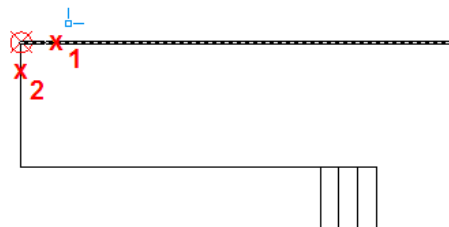
Typically, the first constraints that you apply to a drawing are Coincident constraints. As the name implies, Coincident constraints provide a way of making sure that the endpoints of objects always remain joined. However, the definition is broader. For example, a Coincident constraint accepts the extension of an object as a valid location. In some cases, a Coincident constraint is similar to a Nearest object snap.

Let's create a Coincident constraint between the endpoints of the two lines.

- 2 On the Geometric panel, click Coincident.

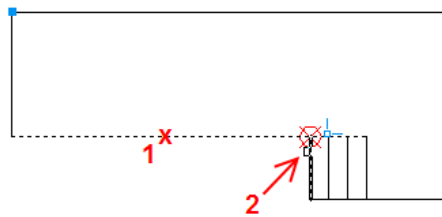


- 3 Click near the endpoints of the horizontal and the vertical lines as shown. This action creates a Coincident constraint that looks like a small blue square at the corner.



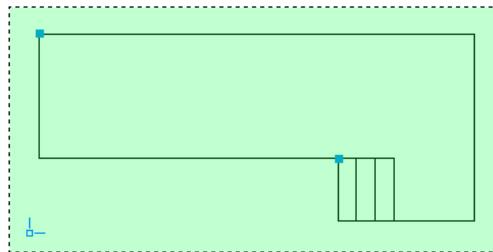
A red point glyph is displayed for each selection. These glyphs work like object snaps, but are limited to Endpoint, Midpoint, and Center. To create a Coincident constraint at a T-intersection between two lines, use the Object option.

- 4 On the Geometric panel, click Coincident again.
- 5 At the Command prompt, press Enter to specify the Object option.
- 6 Select the horizontal line as shown, and then select the vertical line near the endpoint. Make sure that the endpoint glyph is displayed.



You could continue applying Coincident constraints to the other intersections manually, but there is a faster way to apply them.

- 7 On the Geometric panel, click Coincident again.
- 8 At the Command prompt, enter **a** to specify the Autoconstrain option.
- 9 Select all the objects in the deck plan and press Enter.



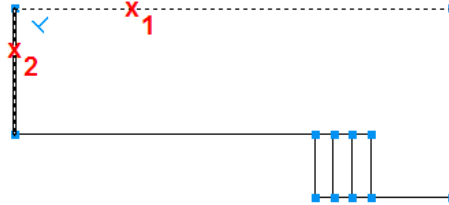
All the Coincident constraints are applied. We will now add the rest of the geometric constraints.

To apply perpendicular constraints

- 1 On the Geometric panel, click Perpendicular.

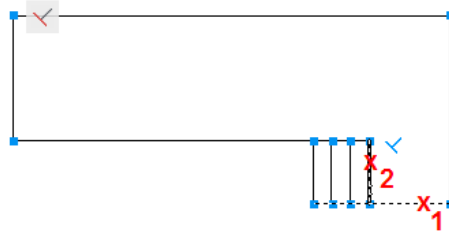


- 2 Select the horizontal and vertical lines as shown.



The order in which you select the two lines makes a difference in some cases. For example, imagine two lines in a V-shape with a Coincident constraint at their intersection. When you apply a Perpendicular constraint, the first line that you select is the reference line. The other line will adjust to the first line. This behavior also applies to several other types of geometric constraints.


- 3 On the Geometric panel, click Perpendicular again.
- 4 Select the horizontal and vertical lines as shown.

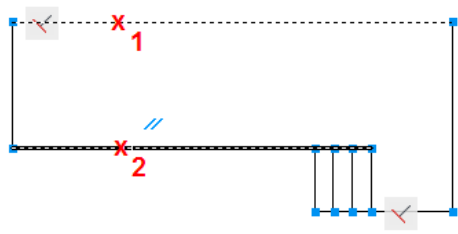


Notice that the two lines do not need to intersect at their endpoints to accept the Perpendicular constraint. In some cases, the lines might not even touch, but can intersect at an extrapolated intersection.

There are several lines in the deck plan that should always be parallel. We will add those constraints next.

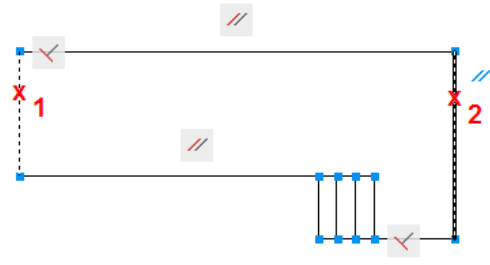
To apply parallel constraints

- 1 On the Geometric panel, click Parallel. 
- 2 Select the two horizontal lines as shown.

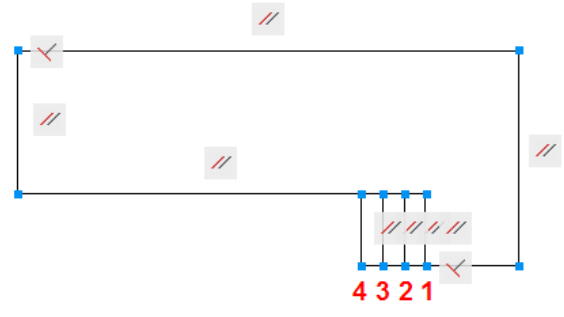


Parallel constraints do not constrain the lengths and offset distances of these lines. They only make sure that the lines remain parallel.

- 3 Click Parallel again.
- 4 Select the two vertical lines as shown.



- 5 Go ahead and apply Parallel constraints to each of the four lines of the stairs. Use the right-most of the four lines as the reference in each case: 1 and 2, 1 and 3, and 1 and 4. You might need to zoom in to select the lines.



It is not critical to make all the lines parallel to the reference line, but this method captures the design intent.


To apply fix constraints to the drawing

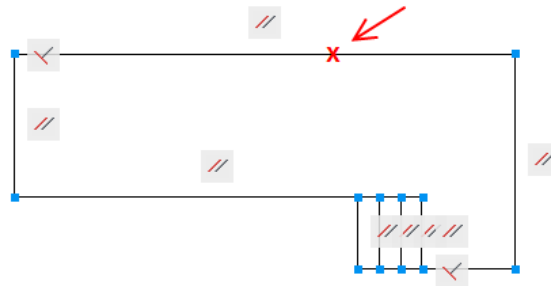
A Fix constraint locks a specified point on an object to a fixed WCS location in the drawing. It can also lock a specified object to a limited range of freedom.

Applying Fix constraints typically is used for one of two purposes:

- Permanently locate an object within a drawing so it cannot be moved or rotated.
- Temporarily hold an object or a point on an object in place while you manipulate other, partially constrained objects.

You can apply Fix constraints to several objects or points on objects in a drawing.

- 1 On the Geometric panel, click Fix. 
- 2 At the Command prompt, enter `o` to specify the Object option.
- 3 Select the horizontal line on the deck plan as shown.



This constraint keeps the selected line segment collinear with an imaginary infinite line, but it does not lock the locations of its endpoints.


Let's apply a Fix Point constraint to an endpoint of the same line.

- 4 On the Geometric panel, click Fix.
- 5 Click the line near the left end.

The second lock icon confirms that the line is now fixed in place. It cannot move or rotate.


To remove constraints

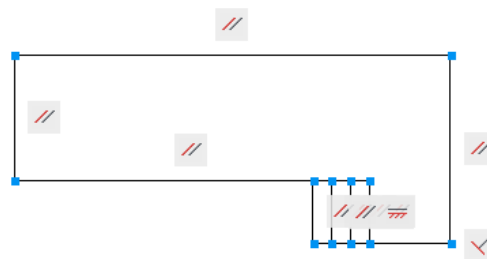
There are several method you can use to remove constraints.

- 1 Right-click the Fix constraint that you just added and click Delete.
Alternatively, you can move your cursor over a constraint icon and press the Delete key. This action removes a single constraint.
- 2 On the Manage panel, click Delete Constraints. 
- 3 Select one of the lines.
All the constraints applied to that line are removed. Alternatively, if you are working within a command and one or more constraints prevent you from making a change, press and release the Ctrl key to relax the constraints on the selected objects. After completing the command, the constraints will be reapplied, if possible.
- 4 On the Manage panel, click Delete Constraints.
- 5 Select all the lines using a Window or Crossing selection.
This action removes all the constraints from the deck plan.

To constrain selected objects automatically

The Autoconstrain feature adds a complete set of geometric constraints to selected objects automatically. Let's try it on the deck plan.

- 1 On the Geometric panel, click Auto Constrain. 
- 2 Select all the lines using a Window or Crossing selection.
All the objects are geometrically constrained to each other. You can now make adjustments, deleting the constraints that you do not want to use and applying others.



Notice from the drawing that Autoconstrain assumed that the bottom horizontal line should always remain horizontal, and that the top step should always be parallel to the right edge of the deck. These and other assumptions are not always going to be correct for your designs. You should always plan to make some adjustments after using Autoconstrain.

- 3 Close the drawing without saving it.

Summary

You have learned how to apply several types of geometric constraints to capture the intent and requirements of the design. However, geometric constraints do not fully constrain the size and shape of the objects in a drawing. To fully constrain a drawing, you need to apply dimensional constraints, which is the subject of the next lesson.

Review Questions

- 1 What is the purpose of a coincident constraint?
- 2 What is the significance of the first object selected when you apply some types of constraints?
- 3 What are Fix constraints?
- 4 What is a fast way to remove all the constraints from a selected object?
- 5 When is it recommended to use Autoconstrain?

Lesson 3: Work with Dimensional Constraints

Time to complete: 10-15 minutes

Learning Objectives

On completing this lesson, you will be able to do the following:

- Describe dimensional constraints.
- Create aligned and angular constraints.
- Change a design by changing the values of the dimensional constraints.
- Plot dimensional constraints for design reviews, and understand the differences between dynamic and annotational constraints.

File Name: *PD_Deck3.dwg*

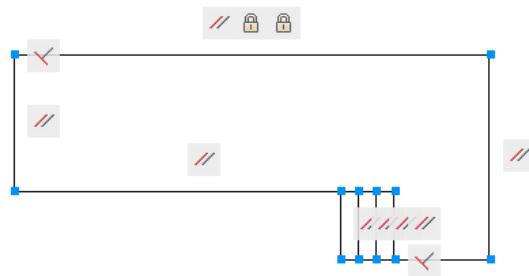
Command: *DIMCONSTRAINT*


Dynamic dimensional constraints control the lengths, radial sizes, and angles of objects. They also control the distances between objects or points on objects. For example, in addition to controlling the lengths of selected objects, you might want to keep the distance *between* lines constant, such as the tread length of stairs.

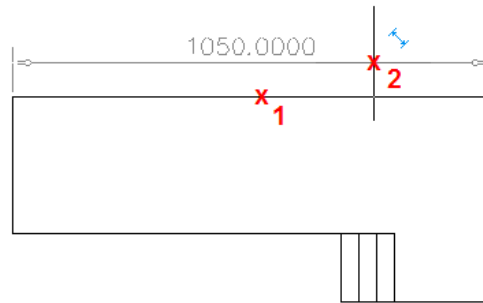
Let's apply dynamic constraints to the drawing of the deck plan.

To create dynamic constraints

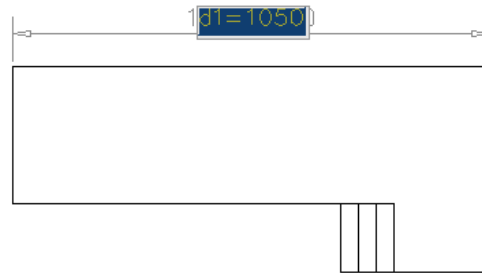
- 1 Open the drawing file, PD_Deck3.dwg.
This drawing is the deck plan with all the geometric constraints applied. Let's verify that the geometric constraints are applied.
- 2 On the Geometric panel, click Show All to display all geometric constraints.



- 3 On the Geometric panel, click Hide All.
- 4 On the Dimensional panel, click Aligned. 
- 5 At the Command prompt, press Enter to specify the Object option.
- 6 Select the horizontal line as shown and then click a location for the dynamic constraint.

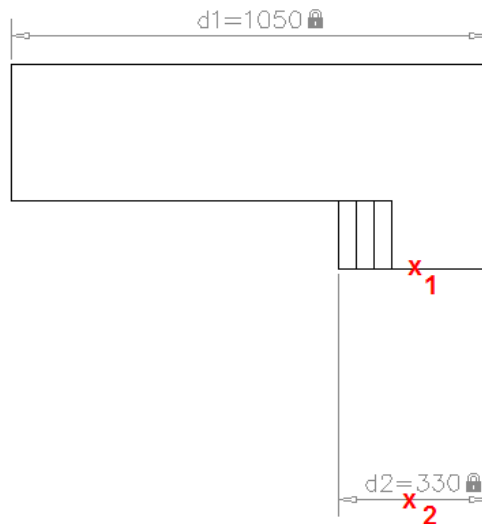


- 7 Press Enter or click anywhere outside the box to accept the current length of the line.

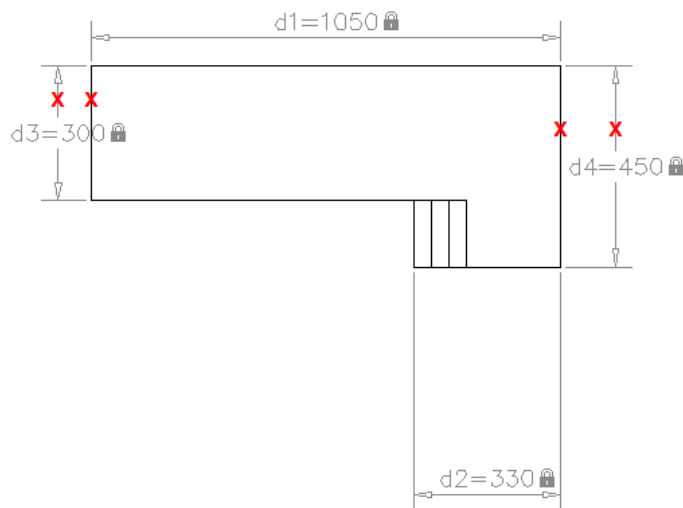


This step provides the opportunity for you to change the length of the line.

- 8 Click Aligned again.
- 9 Create an aligned constraint for the bottom horizontal line as shown. You will need the extra space later.



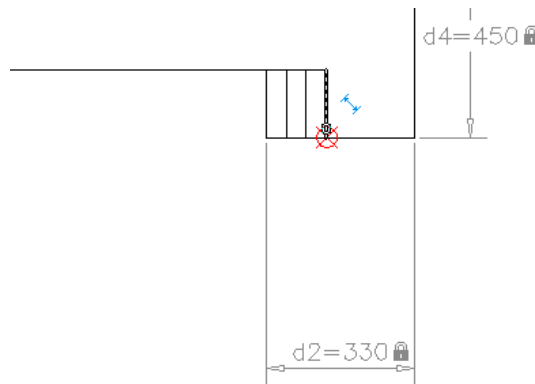
10 Create two more Aligned constraints on the vertical lines as shown.



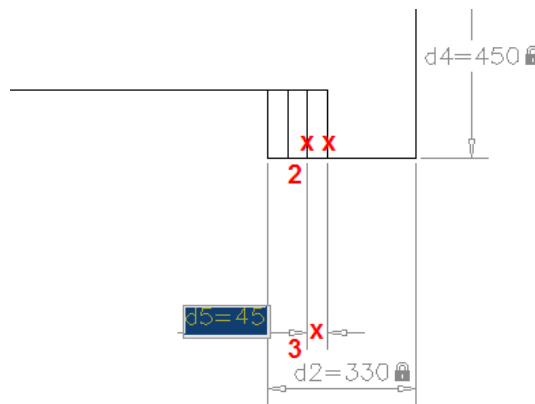
You might wonder why we did not apply Horizontal and Vertical constraints instead of the Aligned constraints. For this design, we want to control the *lengths* of the lines. The Horizontal and Vertical constraints control only the horizontal and vertical distances. This distinction is

important when you work with diagonal lines or later need to rotate a drawing.

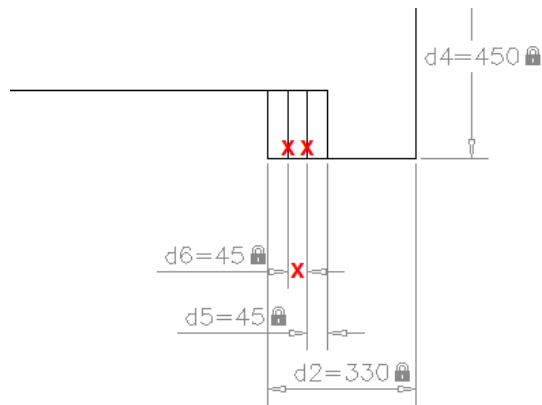
- 11 Zoom into the area of the stairs.
We will apply constraints on the tread length for each step.
- 12 On the Dimensional panel, click Aligned.
- 13 Click the vertical line as shown, making sure that you see the endpoint glyph.



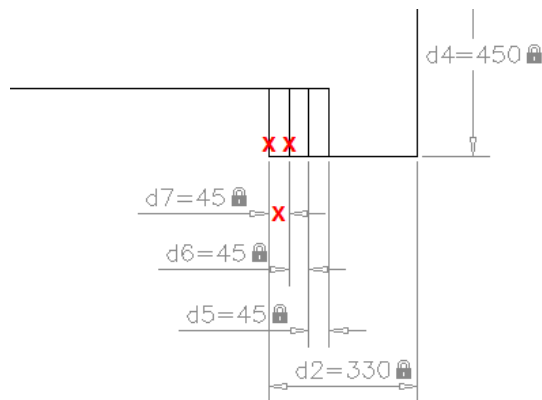
- 14 Click the endpoint of the vertical line to the left, and click a location for the constraint.



- 15 Press Enter or click anywhere outside the box to accept the value of 45.
- 16 Create an Aligned constraint between the next pair of lines as shown.



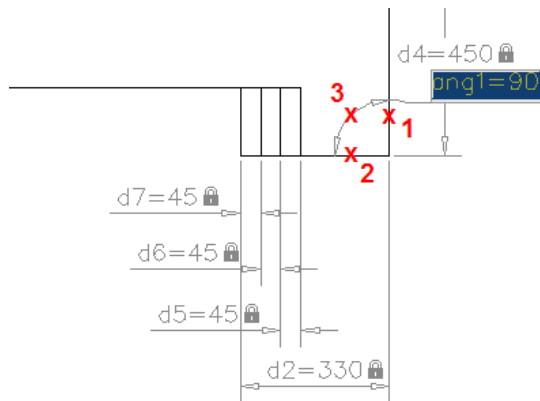
17 Repeat the process for the last pair of lines as shown.



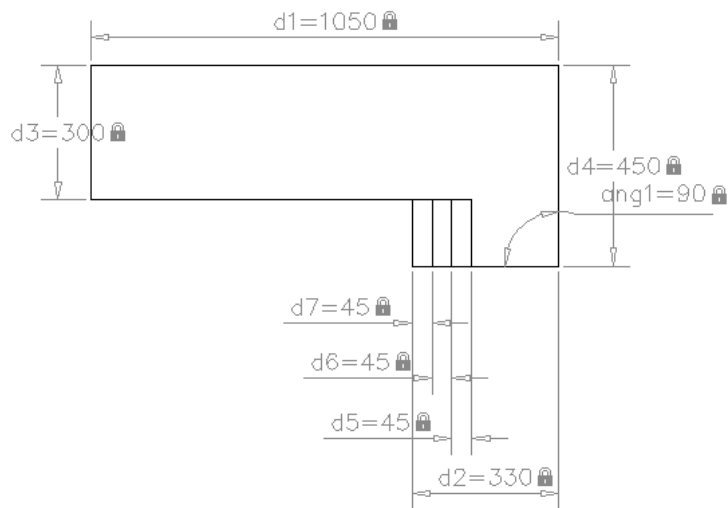
Each of the endpoints of these lines will now maintain a distance of 45 cm from each other, and the parallel geometric constraints will keep the lines parallel.

18 On the Dimensional panel, click Angular.

19 Click the two lines in the corner of the deck as shown.



- 20 Click a location for the constraint, and press Enter or click anywhere outside the box to accept the value of 90 degrees.
Later, you will see why we chose to use an Angular constraint for this corner.
- 21 Zoom out until you can see the entire deck plan as shown.

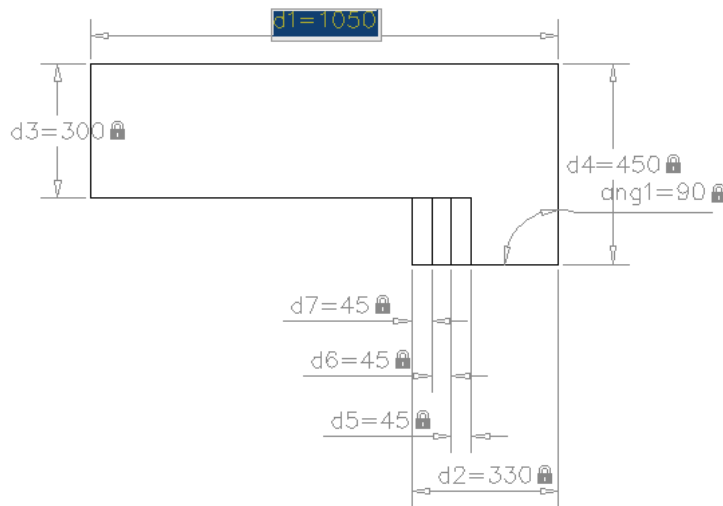


Now that we have fully constrained this deck design, let's change some of the parameters. There are several ways to do this.

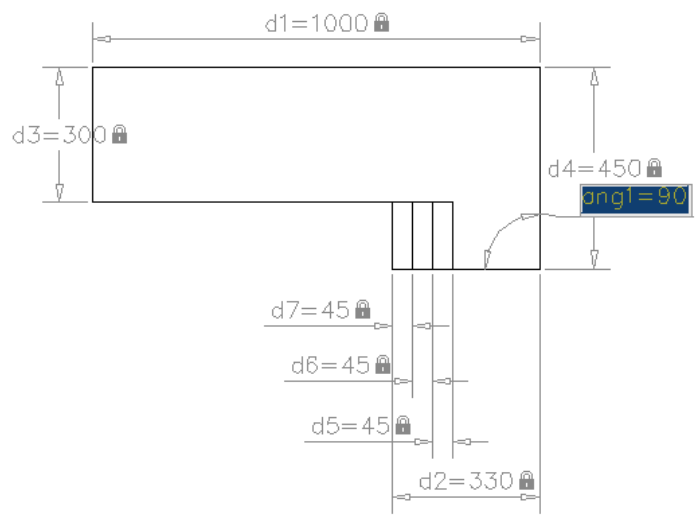
To change dimensional constraints

As mentioned previously, before you modify a constrained design, it's often a good idea to apply one or more Fix constraints first. This keeps those objects from shifting or rotating. You can always delete the Fix constraints later.

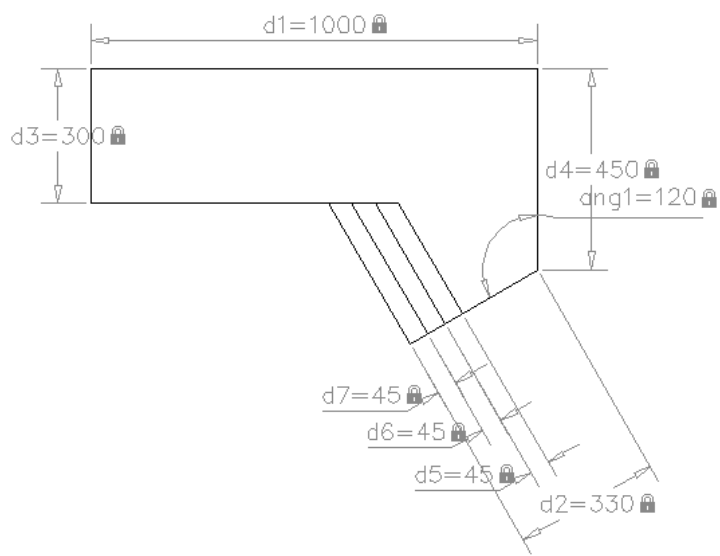
- 1 Turn on the display all Geometric constraints and verify that the two Fix constraints are applied. Then turn off the display of all Geometric constraints.
- 2 Double-click the *d1* dynamic constraint as shown.



- 3 Click within the edit box and enter **1000** as the new value.
The entire deck was shortened slightly. Next, we will try to make the deck plan a little less boring.
- 4 Double-click the *ang1* dynamic constraint as shown.

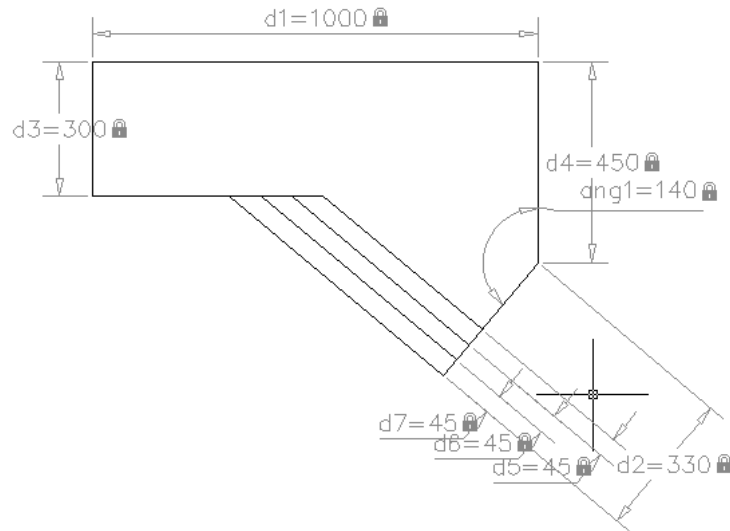


5 Click in the edit box and enter **120** as the new value.



This design is more interesting, but still too timid. Let's make the angle larger.

6 Change the value of the *ang1* dynamic constraint to **140**.



This design is much more interesting. You might want to experiment with other values.

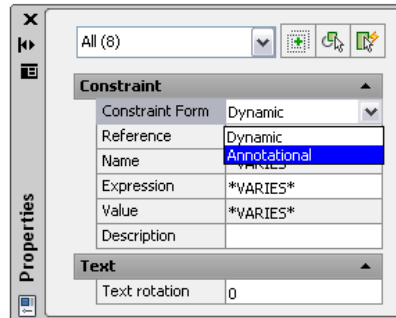
- 7 Close the drawing without saving it.

To plot dimensional constraints

Dynamic constraints do not have the same purpose as the dimensions in a construction document or a manufacturing drawing, nor do they maintain typical dimensioning standards. Thus, dynamic constraints are not plotted with the rest of the drawing. However, you might want to plot them for design reviews. In those circumstances, you can change dynamic constraints into *annotational constraints*.

Annotational constraints are plotted, have a static size, and use the current dimension style.

- 1 Open the Properties palette.
- 2 Select a dynamic constraint.
- 3 In the Properties palette, under Constraint, select Annotational from the Constraint Form drop-down list.



The resulting annotational constraint uses the current dimension style.

- 4 Close the Properties palette.
- 5 (Optional) Plot your drawing to a plotter or a printer.

Summary

You have learned how to apply dimensional constraints and how they work with geometric constraints to control a design. You also learned how to change designs by changing the values of dimensional constraints. Finally, you learned how to change dynamic constraints into annotational constraints for plots to be used in design reviews. Next, you will learn how to add formulas and expressions to a design.

Review Questions

- 1 What is the most commonly used dynamic dimensional constraint that controls the lengths of objects or the distances between them?
- 2 How can you change the value of a dimensional constraint?
- 3 What is the purpose of a Fix constraint?
- 4 What must you do to create a plot that displays dimensional constraints for a design review?

Lesson 4: Control a Design Using Parameters and Expressions

Time to complete: 10-15 minutes

Learning Objectives

On completing this lesson, you will be able to do the following::

- Incorporate formulas and expressions, and manage them with the Parameters Manager.
- Create and name user variables.

File Name: *PD_Deck4.dwg, PD_Areas.dwg*

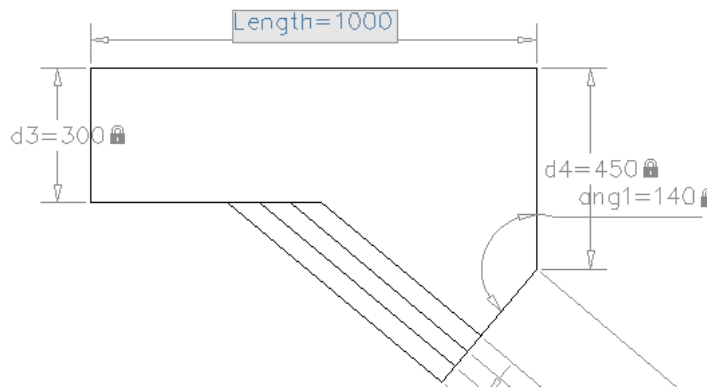
Command: *PARAMETERS, -PARAMETERS*

You can modify dimensional constraints and user variables either directly or with the Parameters Manager.


To rename dimensional constraints

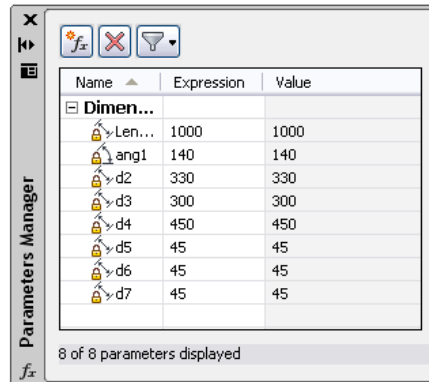
Let's change some dynamic constraints to use more descriptive names.

- 1 Open the drawing file, *PD_Deck4.dwg*.
- 2 Double-click the dynamic constraint, *d1*, and change the *d1* to **Length** as the new name.
- 3 Press Enter or click outside the edit box to accept the change.



Another way to change the name of a dynamic constraint is to use the Parameters Manager.

- 4 On the Parametric tab, Manage panel, click Parameters Manager. 

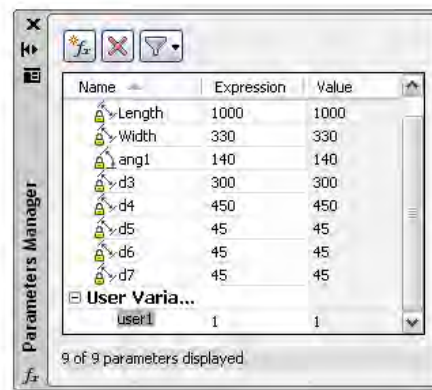


- 5 In the Name column, double-click *d2* and enter **Width**.
- 6 Press Enter or click outside the edit box to accept the change.

To define a user variable

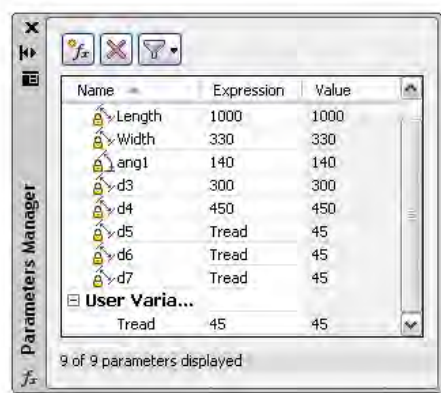
Often, it is convenient to make a single change that affects multiple dynamic constraints. For example, you might want to experiment with several tread widths for the steps in the deck plan.

- 1 Double-click an empty row in the Parameters Manager.



- 2 Change the name of the new user variable from user1 to **Tread**.
- 3 Press Enter or click outside the Parameters Manager palette to accept the new name.

- 4 Change the value in the Expression column from 1 to **45**.
- 5 Press Enter or click outside the Parameters Manager to accept the new value.
- 6 In the Expression column of *d5*, *d6*, and *d7*, enter **Tread**.



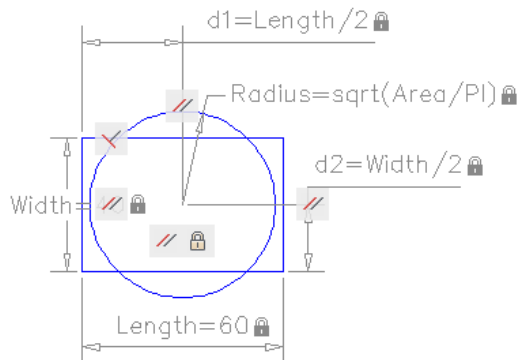
These changes associate the value of each of these distances with the user variable, *Tread*. Let's test your control over the tread widths.

- 7 In the Expression column of the user variable, *Tread*, change the value from 45 to **60**. Then change it to **40**.
The changes are updated automatically in the deck plan.
- 8 Close the drawing without saving it.

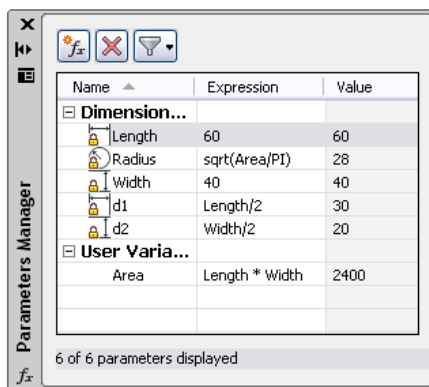
To create dimensional relationships between objects

The Expression column in the Parameters Manager can contain constants, references to dynamic constraints, references to user variables, arithmetic operators, and functions. Consider the following example.

- 1 Open the drawing file, *PD_Areas.dwg*.
This is a fully constrained drawing of a rectangle with a circle at its center. The circle always has the same area as the rectangle. Let's examine the dynamic constraints in detail.
- 2 On the Geometric panel, click Show All and then Hide all to confirm that geometric constraints have been applied.



3 If necessary, open the Parameters Manager. *fx*



4 In the Parameters Manager, click the *Length* row.

As long as your cursor is in the Parameters Manager, the *Length* dynamic constraint remains highlighted in the drawing. *Length* is set to the constant 60.

5 Click the *Width* row and observe the highlighted dynamic constraint.

To center the circle, the *d1* and *d2* dynamic constraints are defined as $\text{Length}/2$ and $\text{Width}/2$. The user variable, *Area*, is defined as the product of *Length* and *Width*, the area of the rectangle.

6 Click the *Radius* row.

The radius of the circle is defined with the expression containing the area of the rectangle, the square root function, and the constant, PI. This sets the radius of the circle to a value that constrains the area of the circle to be equal to the area of the rectangle.

Notice that you can store expressions in a dimensional constraint or in a user variable. A full list of available functions is documented in the *AutoCAD User's Guide* Help topic, *Constrain a Design with Formulas and Equations*.

- 7 Experiment by changing the values for the length and width of the rectangle.

Notice that the Value column displays the current value of the expression in the Expression column. Are you curious what would happen if you set the length of the rectangle to 0 or -1?

- 8 Close the drawing without saving it.

Summary

You have learned how to incorporate mathematical expressions in dimensional constraints and in user variables with the Parameters Manager. These tools provide a method for completely controlling the shape, size, and proportions of a design.

Review Questions

- 1 What are the two places within a parametric drawing that you can store a formula?
- 2 How can you display a list of user variables in a drawing?
- 3 What is the purpose of the Value column in the Parameters Manager?

For more information about working with the Parametric Drawing feature, see the *AutoCAD User's Guide*. Help topic, *Design with Parametric Constraints*.



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