13 Creating a Dimension-Driven Cell

A **dimension-driven cell** is based on a constraint-driven model. It serves as a template for a family of cells that can be derived — solved for a specified set of dimension values. Creating a dimension-driven cell is much different from normal drafting. The intent is to describe the model's structure rather than just drawing its picture.

Preview

In this lesson you will create a dimension-driven model of the profile of a mechanical part and store it in a cell library as a dimension-driven cell. First you will create some **construction** elements, to which you will apply **constraints** in order to achieve various design goals. Only then will you attach the elements that actually depict the profile. The procedure may seem round-about, but the extra work is rewarded by a design that you can re-dimension without re-drawing. The lesson is structured as a series of exercises:

- Creating the structure of the model with construction elements and constraints (see page 13-2).
- Attaching the finished design geometry (see page 13-7).
- Dimensioning the model (see page 13-10).
- Naming and matching dimensions with variables (see page 13-15).
- Creating an equation constraint (see page 13-17).
- Specifying exact dimensions (see page 13-18).
- Creating and testing the cell (see page 13-20).

✍ These exercises are meant to be performed consecutively.

➤ **To prepare for the lesson:**

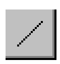
1. The model is in the design file “ddcell.dgn” in MicroStation’s “dgn/learning” directory. Open “ddcell.dgn” and examine the model.
2. Create and open a 2D design file using the seed file “seed2d.dgn.”
3. Attach (or create and attach) a cell library. See “Working with Cell Libraries” in Chapter 7 in the *User’s Guide*.

Exercise: Creating the structure of the model with construction elements and constraints

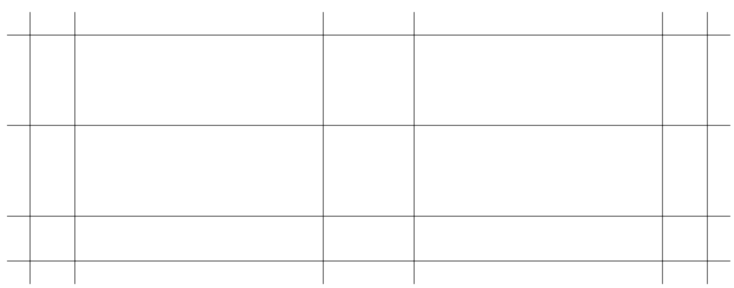
To support this model, you must create a grid of six vertical construction lines, four horizontal construction lines, and two construction circles in the corners. You will also create some construction points at key intersections for later use in attaching the finished geometry.

For now, do not be concerned with the precise dimensions or locations of the elements. It is not necessary to place them as construction elements, since as you use the dimension-driven design tools they are automatically converted to construction elements. Also, when you use the dimension-driven design tools, the elements' attributes will be changed to convey information about the status of the constraint scheme, so do not worry about color, weight, or line style at this point.

➤ **Place the construction lines:**

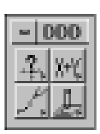


1. From the Main tool bar, tear off the Linear Elements tool box and select the *Place Line* tool (see "Place Line" in Chapter 4 in the *User's Guide*).
2. Place the horizontal and vertical lines shown in the figure. (Place the lines with AccuDraw's Angle field set to 0° and 90°, respectively.)



Construction lines.

➤ **Load the dimension-driven cell creation utility:**



1. From the Utilities menu, choose MDL Applications.

   The MDL settings box opens.
2. In the Available Applications list box, select DD Design and click the Load button.

   The DD Design tool box opens.

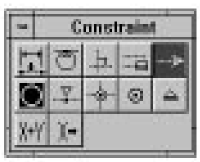
   OR

1. In the Key-in Window, key in MDL LOAD DDDESIGN

   The DD Design tool box opens.

Next, apply **constraints** to maintain the angles of the lines.

➤ Constrain the lines to prevent them from rotating:

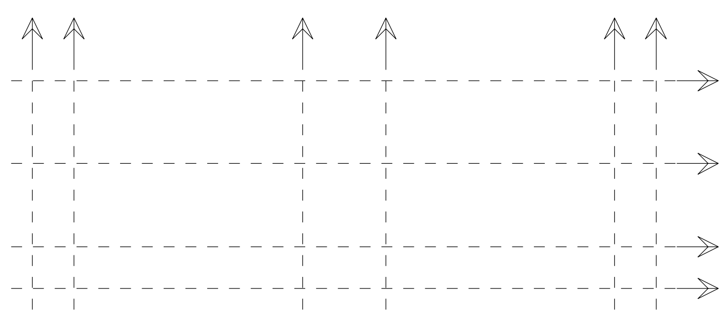


1. From the Tools menu's DD Design sub-menu, choose Constraint.
2. In the Constraint tool box, select the *Fix Angle of Line or Ellipse* tool.
3. Identify a line.
4. Accept the line.
5. Repeat steps 3 and 4 for each of the remaining lines.

   The lines are displayed dashed in yellow, indicating that they are still under-constrained (they cannot rotate, but they can move).

   If the lines disappear when you apply constraints to them, check the view's attributes (Settings menu/View Attributes). You probably have Constructions turned off.

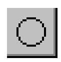
✍ There should be a blue line string that looks something like an arrow at one end of each line. This line string represents the fixed-angle constraint. The size of a constraint element depends on the Active Text Height (Element menu/Text). If you cannot see a constraint or if it is too small or large, adjust the Active Text Height and then update the model by selecting the *Re-solve Constraints* tool from the DD Design tool box and identify one of the lines.



Construction lines with rotation constrained.

Model the rounded corners of the design by means of construction circles. Note that you use circles for the structure. You will attach arcs to them later.

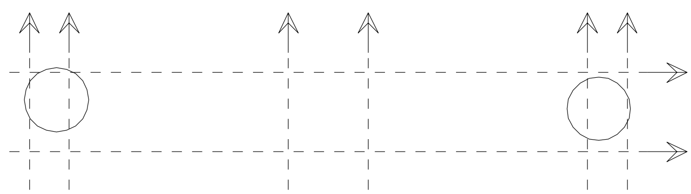
➤ **Place construction circles at each corner:**



1. From the Ellipses tool box, select the *Place Circle* tool (see “Place Circle” in Chapter 4 in the *User’s Guide*).
2. Place two circles.

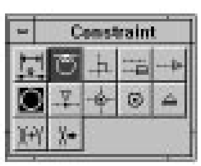
   The exact location and size of the circles is not important — you will apply tangency constraints to fit them exactly into the outside corners and dimensional constraints to control their size.

Construction circles.



Now apply tangency constraints to fit each circle into the corner defined by the adjacent outside lines. This will model the rounds. Do not worry that the radii do not match or if the corner looks ragged at this stage.

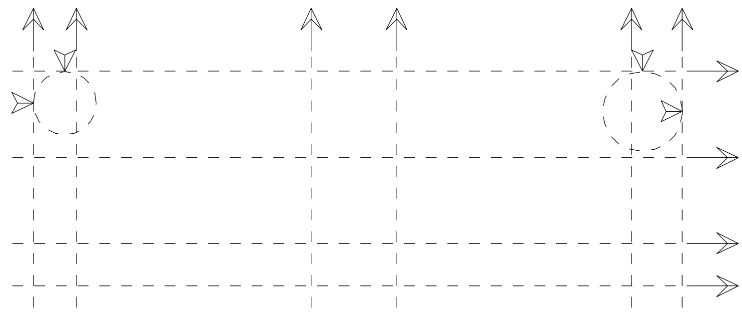
➤ **Apply tangency constraints to the construction circles:**



1. In the Constraint tool box, select the *Constrain Two Constructions to be Tangent* tool.
2. Identify the circle at the upper left.
3. Identify the leftmost vertical line.
4. Accept the point somewhere near the circle.

   This creates a tangency constraint element and pulls the elements together. The circle also turns yellow to show that it is still under-constrained.
5. Identify the circle again.
6. Identify the topmost horizontal line.
7. Accept the point somewhere near the circle.

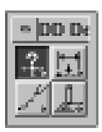
   This creates another tangency (without violating the first).
8. Repeat steps 2 through 7 to constrain the circle at the upper right to touch the topmost horizontal and rightmost vertical lines.



Tangency constraints.

To get a feel for what you have created so far, you will use *Modify and Re-solve Constraints* tool. You already have a system of constraints: fixed angles and circle-line tangencies. You should be able to move the lines and re-size the circles and see that these are maintained. You could also tidy up the arrangement of the lines if they have gotten moved around.

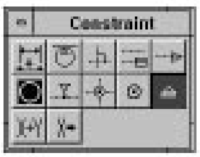
➤ **Modify the construction geometry while maintaining constraints:**



1. In the DD Design tool box, select the *Modify and Re-solve Constraints* tool.
2. Identify the topmost horizontal line (snap if necessary to be sure you have identified the topmost line).
3. Move the pointer.

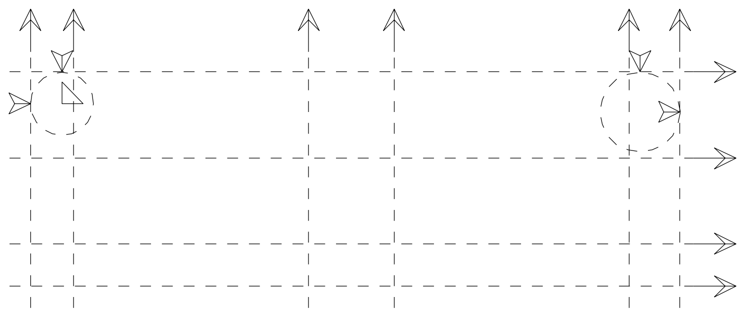
   The line you selected moves with it, and the circles and other lines move and change to maintain the constraints.
4. Enter a data point to accept the modified geometry.

You have almost completed laying out the basic structure of the model. You have specified the basic geometric relationships among the construction elements, and you will go on to specify dimensional constraints between them. But first you will fix the location of a point in the model (the upper left circle) in the design plane as a point of reference for the rest of the construction. The location itself hardly matters. Of course, you should take care not to fix the location too near the edge of the design plane.



➤ **Fix the location of the model in the design plane:**

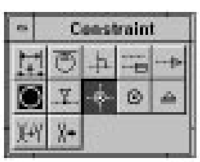
1. In the Constraint tool box, select the *Fix Point at Location* tool.
2. Identify the circle at the upper left.
3. Accept the circle.



Fixing the location of the model.

Finish the construction by placing points at key intersections. You will use these points later on to help define the profile of the finished model.

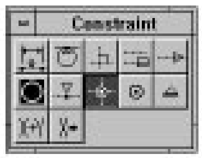
➤ **Constrain points at the intersections of construction lines to define the key slot:**



1. In the Constraint tool box, select the *Constrain Point at Intersection* tool.
2. Identify the topmost horizontal line.
3. Identify the third vertical line from the left.
4. Accept near the intersection of the two lines.
5. Reset.

   This creates a yellow point element at the intersection of the two lines.
6. Repeat steps 2-5 for the intersection of the topmost horizontal line with the fourth vertical line from the left.
7. Repeat steps 2-5 for the intersection of the second horizontal line with the third vertical line.
8. Repeat steps 2-5 for the intersection of the second horizontal line with the fourth vertical line.

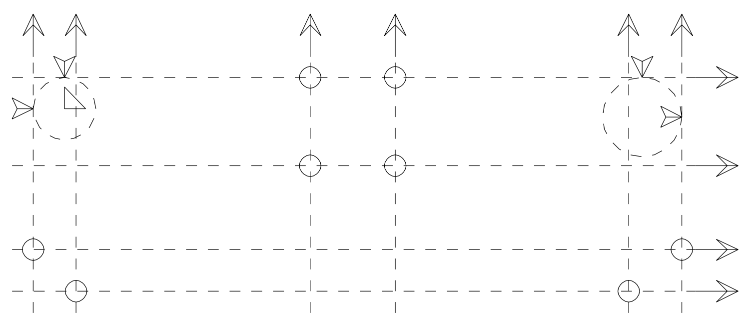
➤ **Constrain points at the intersections of construction lines to define the chamfers:**



1. In the Constraint tool box, select the *Constrain Point at Intersection* tool.
2. Identify the leftmost vertical line.
3. Identify the second horizontal line from the bottom.
4. Accept near the intersection of the two lines.
5. Reset.

   This creates a yellow point element at the intersection of the two lines.
6. Repeat steps 2-5 for the intersections of the vertical line second from the left and the bottom horizontal line. Repeat for the chamfer on the bottom right corner in a similar manner.

Defining chamfers.



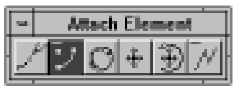
Exercise: Attaching the finished design geometry

What you have created so far does not look much like what you want to plot. You want a profile outlined by a series of lines and arcs, but what you have is a set of construction lines and circles.

In this exercise, you will define the **design geometry** in terms of the construction geometry and the constraints. Since the design geometry will be attached to the constructions, the design geometry will automatically update when you modify the constructions.

First you will draw in the outside radii of the profile. The arcs will run along the construction circles between the tangency constraints. (If you cannot see the blue, arrowhead tangency constraint elements, you may need to adjust the Active Text Height (Element menu/Text) and update the design.)

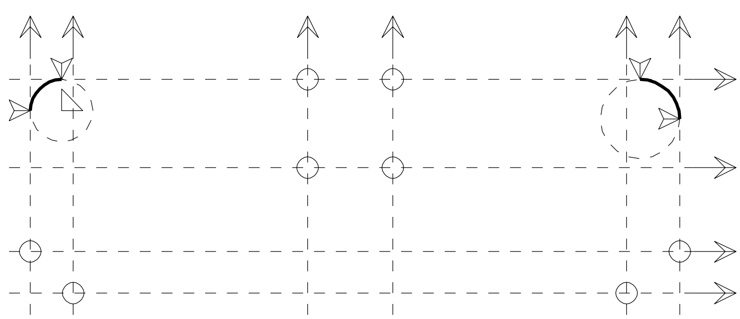
➤ **Attach arcs to the outside rounds:**



1. In the DD Design tool box's Attach Element tool box, select the *Construct Attached Arc* tool.
2. Identify the construction circle at the upper left corner of the design.
3. Identify the topmost tangency constraint by entering a data point on or near the blue element that points to the spot at which the circle and the topmost line touch. Do not accept it yet.
4. Move the pointer around to the left (counter-clockwise).

   You should see an arc running around the circle as you go. The arc will always run counter-clockwise. If you do not see the arc, try increasing the Active Line Weight or changing the Active Color. If you still do not see the arc, you may have missed the tangency constraint; try again.
5. Identify the leftmost tangency constraint by entering a data point on or near the blue element that points to the spot at which the circle and the leftmost line touch.

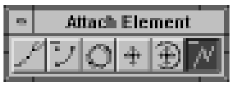
   The arc is placed.
6. Repeat steps 2-5 to attach an arc to the round on the right side of the design. Remember that the arc will run counter-clockwise, so for this one you must start at the rightmost tangency and end at the top-right tangency.



Arcs attached to outside rounds.

You will now finish the profile by “connecting the dots.” Two line strings will do the whole job.

➤ **Attach a line string to outline the sides, bottom and chamfers.**



1. In the DD Design tool box’s Attach Element tool box, select the *Construct Attached Line String or Shape* tool.

2. Identify the tangent constraint at the left edge of the design by entering a data point on or near the blue element that points to the spot at which the leftmost circle and vertical line touch. Do not accept it yet.

As you move the pointer, you should see a dashed line extending from the tangent constraint to the pointer. (If you do not see a dashed line or if the line starts somewhere else [for example, the center of the circle], then you probably missed the tangent constraint. Reset and try again.)

3. Identify each of the points of intersection that you created around the bottom of the design by entering a data point on or near each point (or on the blue, circular intersection constraint that applies to each point).

The line string extends with each data point.

4. Identify the rightmost tangency as the last point on this line string.

5. Reset to finish the line string.

➤ **Attach a line string to outline the top and slot.**

1. Identify the top-left tangent constraint. Be careful not to identify the top-left circle by mistake.

2. Identify the point of intersection immediately to the right.

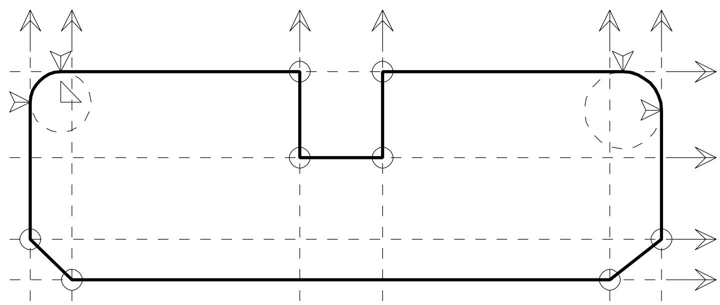
3. Identify the point immediately below that point.

4. Identify the point to the right.

5. Identify the point above.

6. Identify the top-right tangent constraint.
7. Reset to place the line string.

Outlining the top and slot.



Exercise: Dimensioning the model

Now that you can see the model's outline, you can also see that it is a rough approximation, at best, of the desired profile. It has the right kind of shape, but the dimensions are wrong.

It is appropriate now to define the geometry exactly by placing **dimensional constraints**. The geometric constraints you have already placed will serve to hold the construction together and to maintain key relationships. The dimensional constraints that you will place now will let you shape and re-shape the design, subject to those other constraints. *This is the heart of dimension-driven cell creation.*

In the parlance of dimension-driven design, you remove **degrees of freedom** (DOF), or freedom to vary from the model, with each constraint you place. Each dimensional constraint removes one DOF.

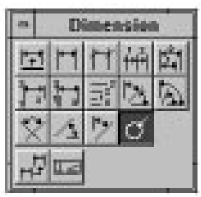
As you add dimensional constraints, MicroStation counts down how many DOF are left — that is, how many dimensions you have left to place. When you have completely specified the model's dimensions, there will be no freedom to vary left in the model, and MicroStation will know exactly how to draw it to size.

As you create constraints and remove DOF from the model, the construction geometry will turn white in response. Any one constraint removes only one DOF from the model, but that DOF may apply to several related aspects of the model.

Notice that MicroStation reports “DOF = 10.” That means you have 10 dimensional constraints to place. (You will specify the exact dimension values in a later exercise.)

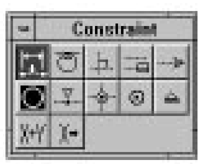
First you will dimension the rounds and convert the radial dimensions to dimensional constraints. Do not worry that the two radii are different. You will match them up later.

➤ **Dimension the radii:**



1. From the Tools menu’s Main sub-menu, choose Dimensioning.

   The Dimensioning tool box opens.
2. In the Dimension tool box, select the *Dimension Element* tool (see “Dimension tool box” in Chapter 13 in the *User’s Guide*).
3. Choose the *Dimension Radial* tool.
4. In the Dimension Radial Tool settings box, turn on Association Lock.
5. Place an associative radius dimension on each of the two construction circles. Do not forget to snap to the circles when placing the dimensions.

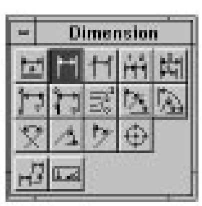


6. In the Constraint tool box, select the *Convert Dimension to Constraint* tool.
7. Identify a radius dimension.

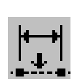
   If the dimension is not associative, the message “Requires an Associative Dimension” is displayed. If so, delete the dimension and try again (repeat step 5).
8. Accept the dimension.
9. Repeat steps 7 and 8 for the other dimension.

Dimension the chamfers by dimensioning the sides of the boxes which define their end points. Do the height first.

➤ **Dimension the height of the chamfers:**



1. In the Dimension tool box, select the *Dimension Size with Arrow* tool (see “Dimension tool box” in Chapter 13 in the *User’s Guide*).
2. Place an associative linear dimension from the end of the bottommost horizontal line to the end of the next horizontal line up. The dimension’s Alignment does not matter.
3. In the Constraint tool box, select the *Convert Dimension to Constraint* tool.



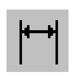
4. Identify the linear dimension.

   If you did not place the dimension between two horizontal lines, the message “Invalid dimension type, targets or alignment” is displayed. Perhaps you placed the dimension along one line or between perpendicular lines, or in some way to an element that is not a construction line. If so, delete the dimension and try again (step 1).

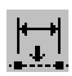
5. Accept the dimension.

Now finish constraining the chamfers. You will make the dimensions match (and make the chamfers square) later.

➤ **Dimension the width of the chamfers:**

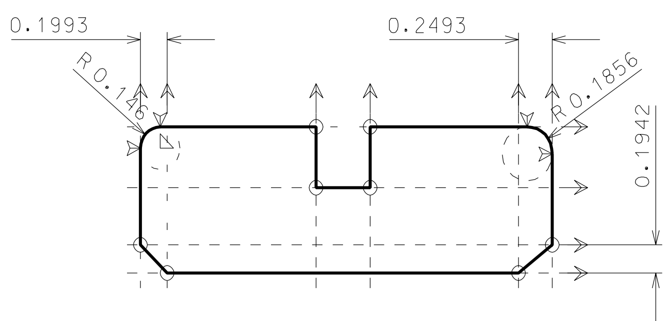


1. Use the *Dimension Size with Arrows* tool to place an associative linear dimension from the end of the leftmost vertical line to the end of the vertical line next to it.



2. Select the *Convert Dimension to Constraint* tool.
3. Identify the linear dimension.
4. Accept the dimension.
5. Repeat steps 1-4 for the width of the chamfer on the right.

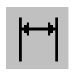
If the dimension turns red and the message “OVER-CONSTRAINED” is displayed, you probably dimensioned from the circle to the line, rather than between the lines. If so, delete the dimension and try again.



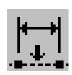
Dimensioning chamfer width.

Dimension the size and location of the slot in the top of the design by dimensioning across the opening and then from the edge of the design to the edge of the slot. Note that this is just one possible way of dimensioning this feature, and you could easily change this part of the overall dimensioning scheme later if you find a better one.

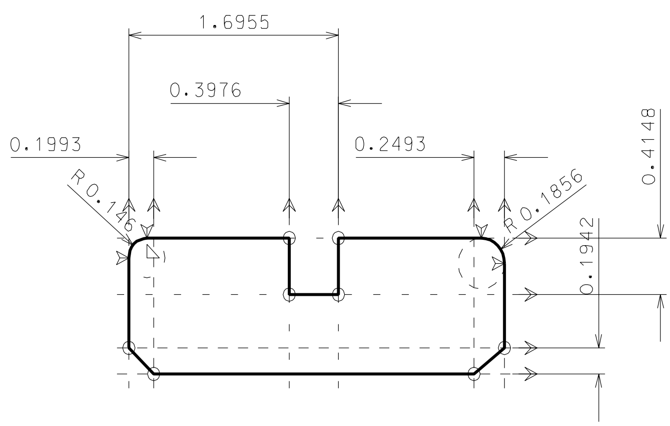
➤ **Dimension the slot:**



1. Use the *Dimension Size with Arrows* tool to place an associative linear dimension between the two vertical lines in the center of the design.
2. Place an associative linear dimension between the top two horizontal lines.
3. Place an associative linear dimension between the leftmost vertical construction line and the line that defines the right wall of the slot.



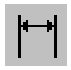
4. Select the *Convert Dimension to Constraint* tool.
5. Identify one of the newly placed dimensions.
6. Accept the dimension.
7. Repeat steps 4-6 for the other dimensions.



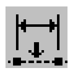
Dimensioning the slot.

Finish the dimensioning scheme, reducing DOF to zero, by constraining the overall height and width of the design. As you can see from the status message displayed last time, you need exactly two more constraints.

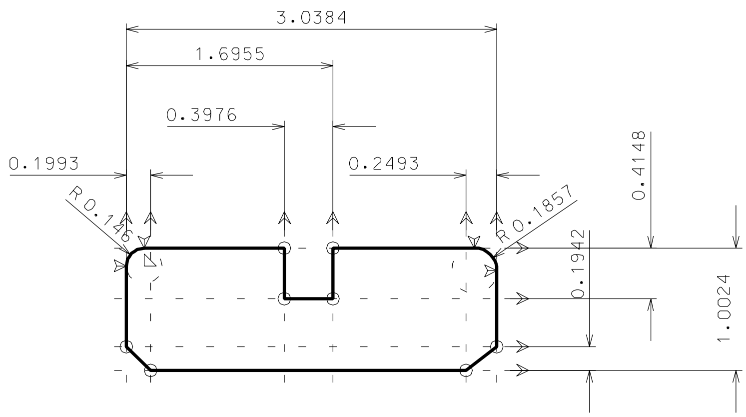
➤ **Dimension the overall size of the profile:**



1. Use the *Dimension Size with Arrows* tool to place an associative linear dimension between the leftmost and rightmost vertical lines.
2. Place an associative linear dimension between the topmost and bottommost horizontal lines.



3. Select the *Convert Dimension to Constraint* tool.
4. Identify one of the newly placed dimensions.
5. Accept the dimension.
6. Repeat steps 3 through 5 for the other dimensions.



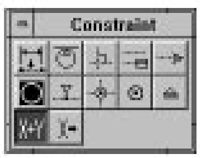
Dimensioning the overall size of the profile.

Exercise: Naming and matching dimensions with variables

The design is now fully constrained, but it is still lopsided. You will match up the two radii and the chamfers with variables. A **variable** is a named value that is stored in a text element. You can assign a variable to a dimensional constraint, thereby making the parameter a synonym for the dimension. Dimensions that are assigned the same variable are the same.

➤ **Equate the radii:**

1. In the Main tool box's Text tool box, select the *Place Text* tool (see "Setting Active Text Attributes" in Chapter 14 in the *User's Guide*).
2. Place a text element with the text: "rad = 0.2" (the value on the right of the "=" sign should be close to the value that the radial dimensions have now).



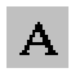
3. In the Constraints tool box, select the *Assign Variable to Dimensional Constraint* tool.
4. Identify the text element you just placed.
5. Identify one of the radial dimensions.
6. Accept the dimension.
7. Identify the text element again.
8. Identify the other radial dimension.
9. Accept the dimension.

   The dimensions take on the value you gave to the variable, and the circles are driven to the same size. There should be no change in the model's DOF. If the DOF increases or the variable is displayed in yellow, then you probably forgot the "=" sign.

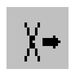
✍ Exact dimension read-out may be very slightly off, depending on where the dimension element itself is located and how the target elements' coordinates are stored in the design file. This is not an indication that the constraint is out of tolerance.

To make the chamfers match and to make them square, you will assign a single variable to three dimensions: the height of the chamfers and both widths.

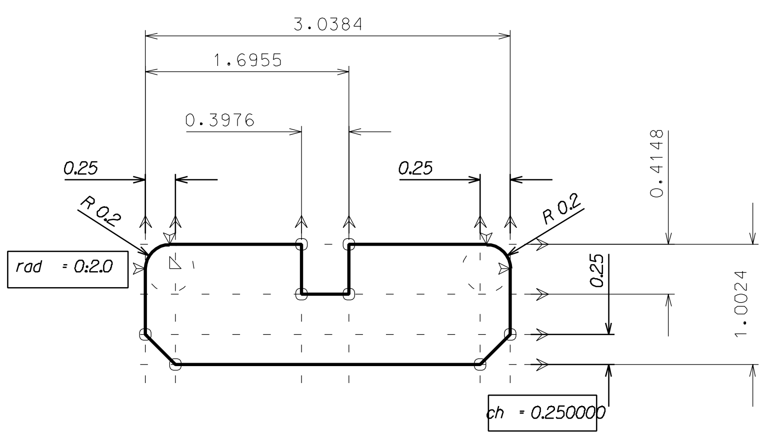
➤ **Equate the chamfers:**



1. Use the *Place Text* tool to place a text element with the following text: “ch = 0.25.” (The value on the right side of the “=” sign should be fairly close to the height and width of the chamfers now.)



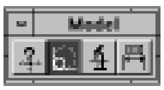
2. Select the *Assign Variable to Dimensional Constraint* tool.
3. Identify the text element you just placed.
4. Identify one of the linear dimensions that constrains the width of a chamfer. (This is a linear dimension between one of the outermost vertical lines and the vertical line next to it.)
5. Accept the dimension.
6. Identify the text element again.
7. Identify the other chamfer width dimension on the other side of the design.
8. Accept the dimension.
9. Identify the text element again.
10. Identify the linear dimension that constrains the height of a chamfer. (This is a linear dimension from the end of the bottommost horizontal line to the end of the next horizontal line up.)
11. Accept the dimension.



Equating chamfers.

The *Describe Selected Construction or Constraint* tool is a special tool for model analysis. It is used to display information about a selected item in a dimension-driven model and about its relationships to other items in the model. This can be useful when you have forgotten how you constructed a design.

➤ **Investigate the model:**



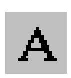
1. In the DD Design tool box's Model tool box, select the *Describe Selected Construction or Constraint* tool.
2. Identify the text "rad = 0.2."
3. Accept the text.

   The message "Parameter: rad" is displayed in the Status Bar, indicating that the selected element is a parameter in the model and that its name is "rad." More importantly, the two dimensional constraints to which the variable "rad" is assigned are highlighted. If you apply the tool to the "ch" variable, the three dimensions to which it is assigned are highlighted.
4. Update the view.

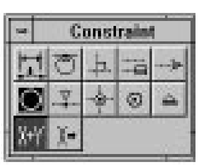
Exercise: Creating an equation constraint

As an example of how you can add more design information to your design, let's specify an algebraic relationship between the overall depth of the profile and the depth of the slot.

➤ **Create the equation and its variables:**



1. Use the *Place Text* tool to place a text element with the text: "depth = slot + 0.6."
2. Place a text element with the text: "depth."
3. Place a text element with the text: "slot = 0.5."

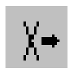


4. In the Constraints tool box, select the *Assign Equation* tool.
5. Identify the three text elements you just placed, starting with the equation, and accept.

   That creates the equation — the "depth" variable now has a value of 1.1 and is well determined (displayed in white).

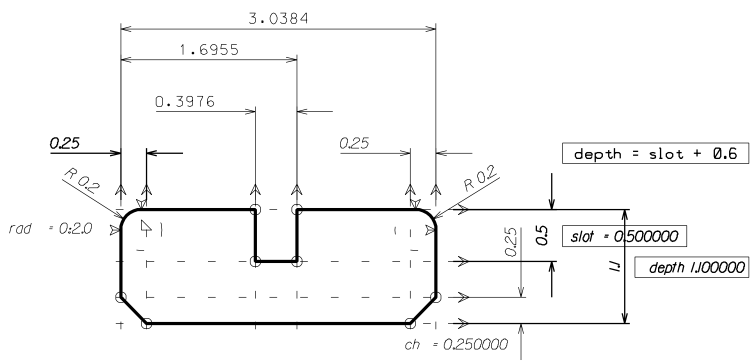
Connect the equation to the model by assigning the two variables to dimensions.

➤ **Assign variables to the slot and depth dimensions:**



1. Select the *Assign Variable to Dimensional Constraint* tool.
2. Identify the text "slot = 0.5."
3. Identify the linear dimension that constrains the distance between the top horizontal line and the horizontal line below it.
4. Accept the dimension.
5. Identify the text "depth 1.1."
6. Identify the linear dimension that constrains the distance between the top and bottom horizontal lines.
7. Accept the dimension.

   The dimensions are forced into the desired relationship.



Assigning variables to the slot and depth dimensions.

Exercise: Specifying exact dimensions

You will actually create the dimension-driven cell and re-dimension it in the next exercise, but first you will insert new dimension values and let MicroStation re-draw the model to fit. This also enables you to clean up the dimensions before placing the model in a cell.

The re-dimensioning utility that you will use in this exercise is closely related to the utility for placing a cell with modified dimension values derived from a dimension-driven cell. In fact, the same dialog box is used for both operations. The re-dimensioning utility can operate on a dimension-driven model or a dimension-driven cell (after it is derived and placed).

✍ The re-dimensioning and dimension-driven cell placement utilities let you modify the values of *all* dimensions, regardless of whether you have assigned named variables to them. If a dimension does not have an assigned variable, then an internal name such as "LLDistance17" is used. (Internal names can change when you add or delete elements in the model — you are likely to see unfamiliar names in the list.) *Naming all dimensions before creating a dimension-driven cell will make it easier to use.*

➤ **Load the re-dimensioning and dimension-driven cell placement utilities:**

1. In the MDL settings box (Utilities menu/MDL Applications), select DDCELL in the Available Applications list box and click the Load button.

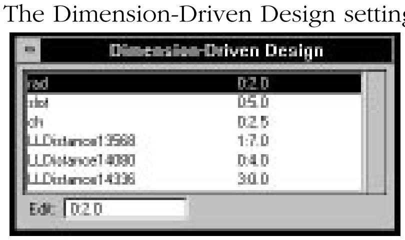
   or

   Key in MDL LOAD DDCELL.

➤ **Modify dimension values and re-solve the model:**

1. Key in MODIFY DIMENSIONS.
2. Identify an element in the design.
3. Accept the element.

   The Dimension-Driven Design settings box opens.

4. In the list box, select a variable or dimension.

   The item's value is displayed in the Edit field.

5. In the Edit field, key in a new value for the variable or dimension.

   The dimension-driven model is modified on the spot to fit the new dimension value. If the new value is out of range, the message "Infeasible Values" is displayed. You can then try a new value.

6. Repeat steps 4 through 5 for as many variables or dimensions as you wish to modify.
7. Dismiss the dialog box or select another tool when done.

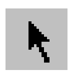
Exact dimension read-out may be very slightly off, depending on where the dimension element itself is located and how the target elements' coordinates are stored in the design file. This is not an indication that the constraint is out of tolerance.

Exercise: Creating and testing the cell

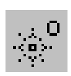
In this final exercise, you will package the model, including all construction lines, constraint elements, text, and dimensions, as a cell. You will also place a few instances of the cell with tailored dimensions. A cell instance derived from a dimension-driven cell definition in a cell library is called a **derived cell**.

Make sure that the view in which you are working is set to display constructions and dimensions.

➤ **Create the cell and designate it as the Active Cell:**



1. Use the *Element Selection* tool to select the model, including all constructions, constraints, dimensions, and text (see "Selecting Elements" in Chapter 6 in the *User's Guide*).



2. Use the *Define Cell Origin* tool (see "Cells tool box" in Chapter 7 in the *User's Guide*) to define the cell origin.
3. From the Element menu, choose Cells.

   The Cell Library settings box opens.
4. Click the Create button.

   The Create New Cell dialog box opens.
5. In the Name field, key in the cell name — for example, SEAL.
6. In the Description field, key in a description — for example, seal profile.
7. Click the Create button.

   The cell is created; the Create New Cell dialog box closes.
8. In the list box in the Cell Library settings box, select the new cell.
9. Click the Placement button.

When you place the cell you will have the choice of whether to save the constraints (and other constructions) along with the finished geometry. By default, the tool assumes that you only want to place the finished geometry and none of the constructions. If you do not save constraints, you cannot modify the cell in place later on.

➤ **Place the cell with modified dimensions:**

1. Key in: PLACE CELL DIMENSION.

   The cell is dynamically displayed and the Dimension-Driven Design dialog box opens.

2. Turn on Save Constraints.

   The construction lines and constraints are dynamically displayed with the cell.

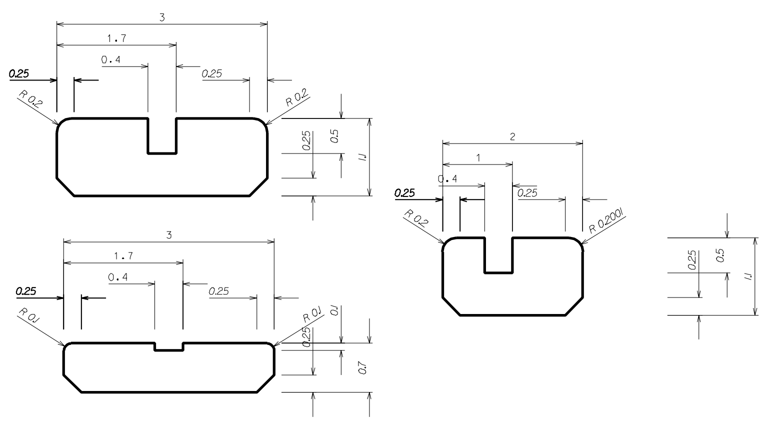
3. Edit the values of the parameters in the dialog box. To edit a value, select the parameter and key in the desired value in the Edit field.

   The cell is dynamically updated to fit the specified dimension values.

4. Enter a data point to position the cell.

5. Repeat steps 3 and 4 to place additional instances with different parameter values.

Placing derived cells.



✓ If you do not want the construction lines and constraints to be displayed or plotted, turn off Constructions for the view in the View Attributes settings box (Settings menu/View Attributes).

This concludes the lesson.