

Chapter 3

Adding Constraints and Dimensions to Sketches

Learning Objectives

After completing this chapter, you will be able to:

- *Add geometric constraints to the sketch.*
- *Control the constraint inference.*
- *View and delete constraints from the sketch.*
- *Dimension the sketch.*
- *Modify dimensions of the sketch.*
- *Measure distances, angles, loops, and areas in the sketch.*


ADDING GEOMETRIC CONSTRAINTS TO A SKETCH

Constraints are applied to the sketched entities to define their size and position with respect to other elements. Also, they are useful for capturing the design intent. As mentioned in Chapter 1, there are twelve types of geometric constraints that can be applied to the sketched entities. These constraints restrict their degrees of freedom and make them stable. Most of these constraints are automatically applied to the entities while drawing. However, sometimes you may need to apply some additional constraints to the sketched entities. These constraints are discussed next.

Perpendicular Constraint

Ribbon: Sketch > Constrain > Perpendicular Constraint


Toolbar: 2D Sketch Panel > Perpendicular

 The **Perpendicular Constraint** forces the selected entity to become perpendicular to the specified entity. To apply this constraint, choose the **Perpendicular Constraint** button from the **Constrain** panel of the **Sketch** tab; you will be prompted to select the first line or an ellipse axis. After you select an entity, you will be prompted to select the second line or ellipse axis. On selecting the second entity, the selected entities will become perpendicular. Figure 3-1 shows two lines before and after adding this constraint.

Parallel Constraint

Ribbon: Sketch > Constrain > Parallel Constraint

Toolbar: 2D Sketch Panel > Perpendicular > Parallel

 The **Parallel Constraint** forces the selected entity to become parallel to the specified entity. The entities to which this constraint can be applied are lines and ellipse axes. To apply this constraint, choose the **Parallel Constraint** button from the **Constrain** panel of the **Sketch** tab; you will be prompted to select the first line or ellipse axis. After you select an entity, you will be prompted to select the second line or ellipse axis. On selecting the second entity, the two entities will become parallel. Figure 3-2 shows two lines before and after adding this constraint.

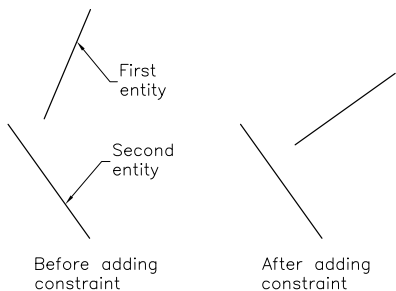


Figure 3-1 Applying the *Perpendicular* constraint

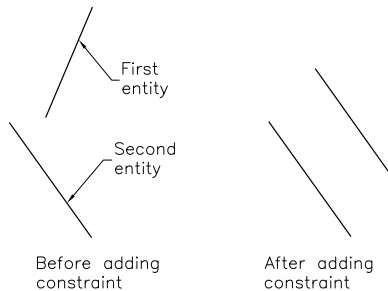


Figure 3-2 Applying the *Parallel* constraint

Tangent Constraint

Ribbon: Sketch > Constrain > Tangent
Toolbar: 2D Sketch Panel > Perpendicular > Tangent



The **Tangent** constraint forces the selected line segment or curve to become tangent to another curve. To apply this constraint, choose the **Tangent** button from the **Constrain** panel of the **Sketch** tab; you will be prompted to select the first curve. After you select the first curve, you will be prompted to select the second curve. The curves that can be selected are lines, circles, ellipses, or arcs. Figures 3-3 and 3-4 show the use of the **Tangent** constraint.

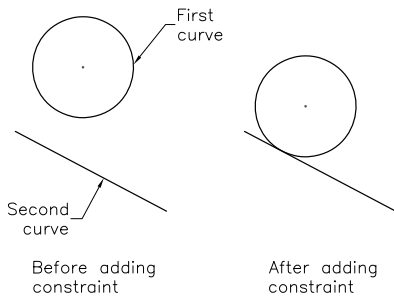


Figure 3-3 Applying the Tangent constraint

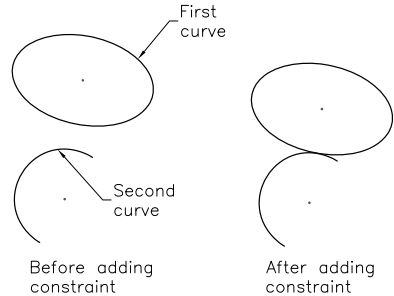


Figure 3-4 Applying the Tangent constraint

Coincident Constraint

Ribbon: Sketch > Constrain > Coincident Constraint
Toolbar: 2D Sketch Panel > Perpendicular > Coincident



The **Coincident Constraint** is used to force two points or a point and a curve to become coincident. To apply this constraint, choose the **Coincident Constraint** button from the **Constrain** panel of the **Sketch** tab; you will be prompted to select the first curve or point. After you select the first curve or point, you will be prompted to specify the second curve or point. Note that either the first or the second entity selected should be a point. The points include sketch points, endpoints of a line or an arc, or center points of circles, arcs, or ellipses.

Concentric Constraint

Ribbon: Sketch > Constrain > Coincident Constraint
Toolbar: 2D Sketch Panel > Perpendicular > Concentric



The **Concentric Constraint** is used to force two curves to share the same location of center points. The curves that can be made concentric include arcs, circles, and ellipses. When you invoke this constraint, you will be prompted to select the first arc, circle, or ellipse. After making the first selection, you will be prompted to select the second arc, circle, or ellipse. Select the second entity to be made concentric with the first entity.

**Note**

If you apply a constraint that over-constrains a sketch, Autodesk Inventor will display a message box informing that adding this constraint will over-constrain the sketch, see Figure 3-5. Over-constrained is a situation where the number of dimensions or constraints exceeds the required number that can be applied to the sketch.

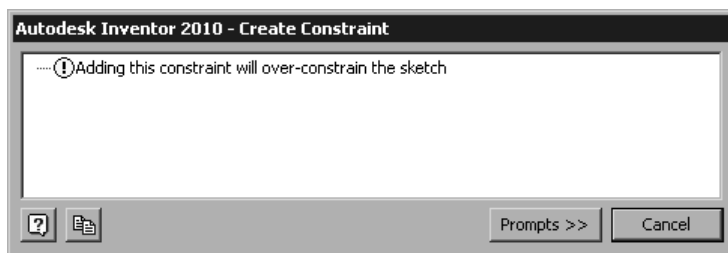


Figure 3-5 Message box informing that the sketch will be over-constrained

Collinear Constraint

Ribbon: Sketch > Constrain > Collinear Constraint
Toolbar: 2D Sketch Panel > Perpendicular > Collinear



The **Collinear Constraint** forces the selected line segments or ellipse axes to be placed in the same line. When you invoke this constraint, you will be prompted to select the first line or ellipse axis. After making the first selection, you will be prompted to select the second line or ellipse axis. Select the entity to be made collinear with the first entity.



Tip. To select an ellipse axis, move the cursor close to the ellipse. Depending on whether the cursor is close to the major axis or the minor axis, the particular axis will be highlighted. When the required axis is highlighted, select it using the left mouse button.

Horizontal Constraint

Ribbon: Sketch > Constrain > Horizontal Constraints
Toolbar: 2D Sketch Panel > Perpendicular > Horizontal



The **Horizontal Constraints** forces the selected line segment, ellipse axis, or two points to become horizontal, irrespective of their original orientation. When you invoke this constraint, you will be prompted to select a line, an ellipse axis, or the first point. If you select a line or an ellipse axis, it will become horizontal. If you select a point, you will be prompted to select a second point. The points, in this case, can also include the center points of arcs, circles, or ellipses.

Vertical Constraint

Ribbon: Sketch > Constrain > Horizontal Constraints
Toolbar: 2D Sketch Panel > Perpendicular > Vertical



The **Vertical Constraint** is similar to the **Horizontal Constraints**, with the difference that this constraint forces the selected entities to become vertical.



Tip. You can use the **Horizontal** or **Vertical** constraint to line up arcs, circles, or ellipses in the same horizontal or vertical direction by selecting their center points.

Equal Constraint

Ribbon: Sketch > Constrain > Equal
Toolbar: 2D Sketch Panel > Perpendicular > Equal



The **Equal** constraint can be used for line segments or curves. If you select two line segments, this constraint will force the length of one of the selected line segments to become equal to the length of the other selected line segment. In case of curves, this constraint will force the radius of one of the selected curves to become equal to that of the other selected curve. Note that if the first selection is a line, also the second selection has to be a line. Similarly, if the first selection is a curve, also the second selection also has to be a curve.

Fix Constraint

Ribbon: Sketch > Constrain > Fix
Toolbar: 2D Sketch Panel > Perpendicular > Fix



This constraint is used to fix the orientation or location of the selected curve or point with respect to the coordinate system of the current drawing. If you apply this constraint to a line or an arc, you cannot move them from their current locations. However, you can change their length by selecting one of their endpoints and then dragging it. If you apply this constraint to a circle or an ellipse, you cannot edit either of these entities by dragging. Once you apply this constraint to an entity, its color changes from black to blue.

Symmetric Constraint

Ribbon: Sketch > Constrain > Symmetric
Toolbar: 2D Sketch Panel > Perpendicular > Symmetric



This constraint is used to force the selected sketched entities to become symmetrical about a selected sketched line segment. On invoking this constraint, you will be prompted to select the first sketched entity. Note that you can select only one entity at a time to apply this constraint. Once you have selected the first sketched entity, you will be prompted to select the second sketched entity. After doing so, you will be prompted to select the symmetry line. As soon as you select it, the second selected entity will become symmetric to the first entity. After you have applied this constraint to one set of entities, you will again be prompted to select the first and second sketched entities. However, this time you will not be prompted to select the line of symmetry. The last line of symmetry will be automatically selected to add this constraint. Similarly, you can apply this constraint to other entities.

If the line of symmetry is different for applying the symmetric constraint to different entities in the sketch, you will have to restart the process of applying this constraint by right-clicking and choosing the **Restart** option from the shortcut menu. This is because the first symmetry

line is used to apply this constraint to all the sets of entities you select. However, if you restart applying this constraint, you will be prompted to select the line of symmetry again.

Smooth Constraint

Ribbon: Sketch > Constrain > Smooth (G2)
Toolbar: 2D Sketch Panel > Perpendicular > Smooth (G2)



This constraint is used to apply curvature continuity between a spline and an entity connected to it. The entities that can be selected to apply this constraint include a line, arc, or another spline. Note that these entities should be connected to the spline.

VIEWING THE CONSTRAINTS APPLIED TO A SKETCHED ENTITY

Ribbon: Sketch > Constrain > Show Constraints
Toolbar: 2D Sketch Panel > Show Constraints



You can view all constraints that are applied to the entities of a sketch by choosing the **Show Constraints** button from the **Constrain** panel of the **Sketch** tab. When you invoke this tool and move the cursor close to any sketched entity, it will be highlighted and boxes will be displayed after a pause. These boxes show the symbols of all constraints that are applied to the entity. The symbols of the constraints will be highlighted in yellow box. Select the entity to retain the constraint box; the constraint box will be displayed with the constraints in a white background. Figure 3-6 shows the constraint boxes along with the constraints applied to the lines. You can move this box by selecting it and dragging. To close a box, choose the cross (X) on the extreme right of the box. In the case of **Coincident Constraint**, the constraint applied on a point is highlighted in yellow, instead of a box. To view the symbols, move the cursor over the highlighted yellow point; the yellow point will turn red and the symbols will be displayed in boxes, refer to Figure 3-6.

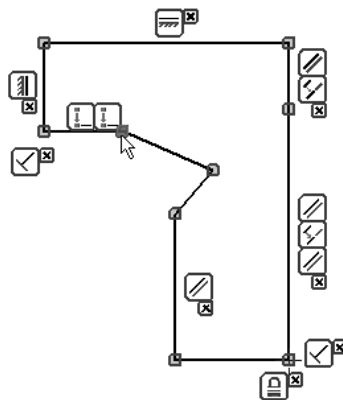


Figure 3-6 The constraint box showing the constraints applied to the sketch

If you move the cursor close to a constraint in the constraint box, it will be highlighted in yellow and the entities to which the constraint is applied are highlighted in red. For example, if you take the cursor close to the perpendicular constraint, the vertical line will also be highlighted along with the horizontal line, suggesting that the horizontal line is perpendicular to the vertical line.



Tip. You can also display the constraints applied to all the entities in the drawing. To display all the constraints, right-click to display the shortcut menu and choose the **Show All Constraints** option; separate boxes will be displayed showing the constraints on all the entities. Similarly, to hide all constraints, right-click and choose the **Hide All Constraints** option from the shortcut menu.

CONTROLLING CONSTRAINTS AND APPLYING THEM AUTOMATICALLY WHILE SKETCHING

You can control and select the constraints that need to be applied automatically, as well as, select the geometry to which they will be applied. The tools and the procedure of selecting the constraints and the geometry are discussed next.

Selecting Constraints

Ribbon: Sketch > Constrain > Constraint Inference



By default, all possible constraints will be applied automatically on the sketching entities while drawing the sketches. However, you can also specify the constraints that need to be applied automatically and also the geometry to which they will be applied while sketching. To do so, invoke the **Constraint Inference** tool from the **Constrain** panel of the **Sketch** tab and right-click anywhere in the drawing window; a shortcut menu will be displayed. Choose **Constraint Options** from the shortcut menu; the **Constraint Options** dialog box will be displayed, as shown in Figure 3-7. The options in this dialog box are discussed next.

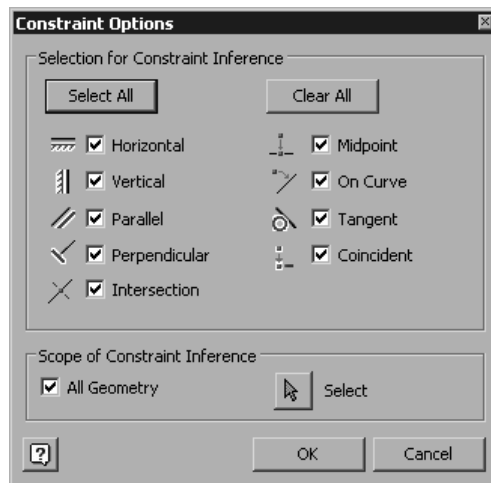


Figure 3-7 The *Constraint Options* dialog box

Selection for Constraint Inference Area

In this area, nine types of constraints and two buttons are available. All the constraints in this area are selected by default. However, if you need to clear all the constraints, choose the **Clear All** button. You can manually select or clear the required constraint by selecting

the corresponding check box provided on the right of the constraint symbols. The selected constraints will be applied automatically to the geometry while sketching.

Scope of Constraint Inference Area

This area is used to set the geometry to which constraint is applied while drawing. By default, the **All Geometry** check box is selected to apply the constraint to all the active sketches. If you clear this check box, the **Select** button will be activated automatically. You can use this button to select the geometry to which the constraints will be applied.

Applying Constraints

Ribbon: Sketch > Constrain > Constraint Persistence



To apply the constraints selected in the **Constraint Options** dialog box, you need to choose the **Constraint Persistence** button from the **Constrain** panel of the **Sketch** tab. This is a toggle button and if you choose it, the **Constraint Inference** button will be activated and all the constraints selected earlier in the **Constraint Options** dialog box will be applied to the sketches while drawing them. You can also switch off the inference of the constraint by choosing this button again.



Tip. The remaining three constraints **Coincident**, **Fix**, and **Symmetric** are not provided in the **Constraint Options** dialog box. By default, the **Coincident** constraint is applied whenever it is possible. You can apply the **Fix** and **Symmetric** constraints manually according to your requirement.

DELETING GEOMETRIC CONSTRAINTS

Autodesk Inventor allows you to delete the constraints applied to the selected entities. To delete constraints, first you need to invoke the constraint box using the **Show Constraints** button. Once the constraints are displayed, exit the **Show Constraints** tool by pressing the ESC key. Now, move the cursor over the constraint that you want to delete; it will be highlighted in yellow. Click the left mouse button to select the constraint; a red box will appear around the constraint. Now, move the cursor away, right-click, and then choose **Delete** from the shortcut menu, see Figure 3-8. The selected constraint will be deleted and removed from the constraint box. Similarly, you can delete all unwanted constraints from the sketch.

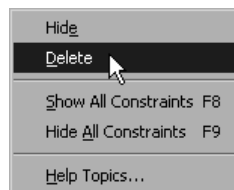


Figure 3-8 Deleting constraints using the shortcut menu



Tip. When you move the cursor close to the constraint in the constraint box, its references will be highlighted in the sketch. For example, if you move the cursor over the **Perpendicular** constraint, the lines on which this constraint is applied will be highlighted. This allows you to confirm that the constraint selected is correct.



Note

The total number of constraints and dimensions required to fully constrain a sketch is displayed at the lower right corner of the drawing window.

ADDING DIMENSIONS TO SKETCHES

Ribbon: Sketch > Constrain > Dimension
Toolbar: 2D Sketch Panel > General Dimension



After drawing a sketch and adding constraints to it, dimensioning is the next most important step in creating a design. As mentioned earlier, Autodesk Inventor is a parametric solid modeling package. The parametric property ensures that irrespective of its original size, the selected entity is driven by the specified dimension value.

Therefore, whenever you modify or apply dimension to an entity, it is forced to change its size with respect to the specified dimension value. The type of dimension to be applied varies according to the type of entity selected. For example, if you select a line segment, linear dimensions will be applied and if you select a circle, diameter dimensions will be applied. Note that all these types of dimensions can be applied using the same dimensioning tool. While dimensioning, you can set the priority for editing a dimension value as soon as you place it. To set the priority, choose the **Dimension** button from the **Constrain** panel of the **Sketch** tab and then right-click; a shortcut menu will be displayed. Choose **Edit Dimension** from this menu, see Figure 3-9. As soon as you place the dimension, the **Edit Dimension** toolbar will be displayed, see Figure 3-10. This toolbar is used to modify the dimensions of an entity. The selected entity will be driven to the dimension value defined in this toolbar.

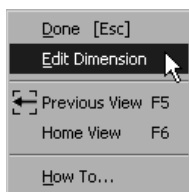


Figure 3-9 Setting the priority for editing dimensions



Figure 3-10 The Edit Dimension toolbar

You can enter a new value for the dimension or choose the button on the right of this toolbar to accept the default value.

If you do not want to edit the dimensions after you place them, invoke the **Dimension** tool and then right-click to display the shortcut menu. Clear the check mark on the left of the **Edit Dimension** option by choosing it again. When you place a dimension now, the **Edit Dimension** toolbar will not be displayed. To edit the dimension value in this case, click on it after placing, if the **Dimension** tool is still active. If the tool is not active, double-click on the dimension; the **Edit Dimension** toolbar will be displayed. Enter the new dimension value in this edit box. The dimensioning techniques available in Autodesk Inventor are discussed next.

Linear Dimensioning

The linear dimensions are defined as the dimensions that specify the shortest distance between two points. You can apply linear dimensions directly to a line or select two points or entities to apply the linear dimension between them. The points that you can select include the endpoints of lines, splines, or arcs, or the center points of circles, arcs, or ellipses. You can dimension a vertical or a horizontal line by directly selecting it. As soon as you select it, the dimension

will be attached to the cursor. You can place the dimension at any desired location. If the priority for editing the dimensions is set, the **Edit Dimension** toolbar will be displayed as soon as you place the dimension. To place the dimension between two points, select the points one by one. After selecting the second point, right-click to display the shortcut menu, as shown in Figure 3-11. In this menu, choose the dimension type. If you choose **Horizontal**, the horizontal dimension will be placed between the two selected points. If you choose **Vertical**, the vertical dimension will be placed between the two selected points. If you choose **Aligned**, the aligned dimension will be placed between the two selected points. Figure 3-12 shows the linear dimensioning of lines and Figure 3-13 shows the linear dimensioning of two points.



Figure 3-11 *Shortcut menu displaying various options to dimension two points*

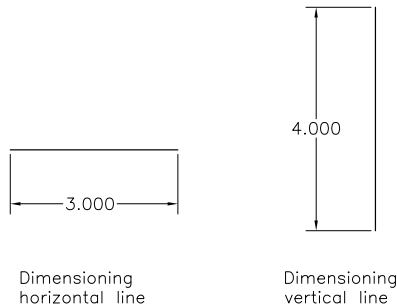


Figure 3-12 *Linear dimensioning of lines*

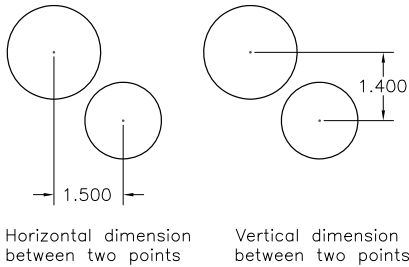


Figure 3-13 *Linear dimensioning of two points*

You can also apply a horizontal or vertical dimension to an inclined line, see Figure 3-14. To apply these dimensions, select the inclined line and then right-click; a shortcut menu similar to the one shown in Figure 3-11 will be displayed. In this menu, choose **Horizontal** to place the horizontal dimension and choose **Vertical** to place the vertical dimension.

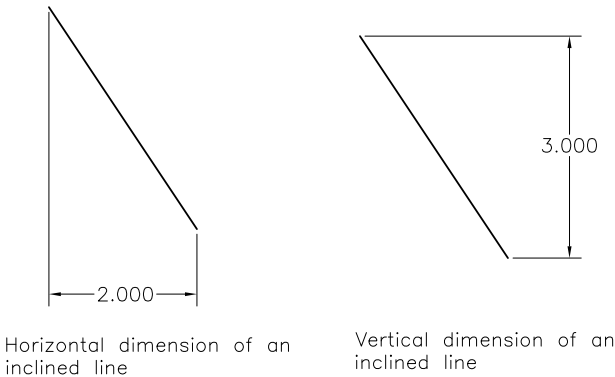


Figure 3-14 *Linear dimensioning of an inclined line*

Aligned Dimensioning

The aligned dimensions are used to dimension lines that are not parallel to the X or Y-axis. This type of dimension measures the actual distance of the aligned lines or the lines drawn at a certain angle. To apply the aligned dimension, select the inclined line and then right-click; a shortcut menu will be displayed, refer to Figure 3-11. Choose the **Aligned** option from the shortcut menu; the aligned dimension of the selected line will be attached to the cursor. Next, click in the drawing window to specify the location of the aligned dimension. You can also apply aligned dimension between two points. The points include the endpoints of lines, splines, or arcs or the center points of arcs, circles, or ellipses. To apply the aligned dimension between two points, invoke the **Dimension** tool. Next, select the two points and right-click; a shortcut menu will be displayed. Choose the **Aligned** option from the shortcut menu. Figures 3-15 and 3-16 show the aligned dimensions applied to various objects.

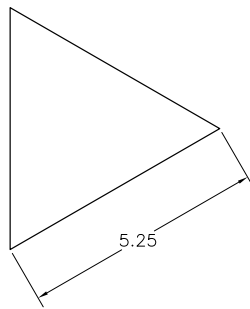


Figure 3-15 Aligned dimension of a line

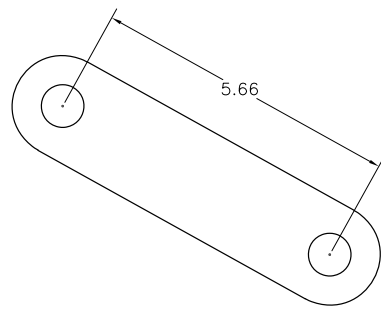


Figure 3-16 Aligned dimension between two points

Angular Dimensioning

The angular dimensions are used to dimension angles. You can select two line segments or use three points to apply the angular dimensions. You can also use angular dimensioning to dimension an arc. All these options of angular dimensioning are discussed next.

Angular Dimensioning Using Two Line Segments

You can directly select two line segments to apply angular dimensions. Invoke the **Dimension** tool and then select a line segment using the left mouse button. Instead of placing the dimension, select the second line segment. Now, place the dimension to measure the angle between the two lines. While placing the dimension, you need to be careful about the point where you place the dimension. This is because depending on the location of the dimension placement, the vertically opposite angles will be displayed. Figure 3-17 shows the angular dimension between two lines and Figure 3-18 shows the dimension of the vertically opposite angle between two lines. Also, depending on the location of the dimension, the major or minor angle value will be displayed. Figure 3-19 shows the major angle dimension between two lines and Figure 3-20 shows the minor angle dimension between the same set of lines.

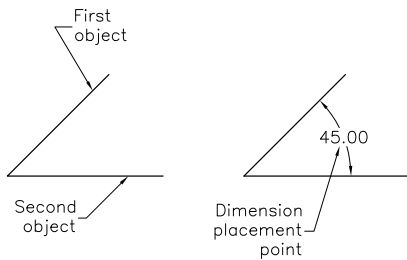


Figure 3-17 Angular dimensioning

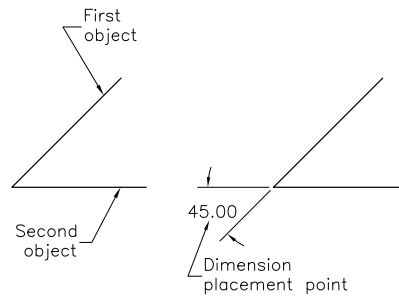


Figure 3-18 Vertically opposite angle

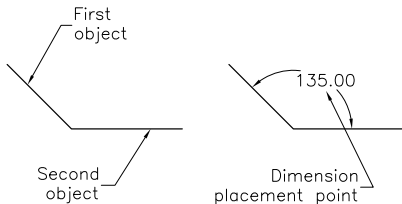


Figure 3-19 Major angle dimension

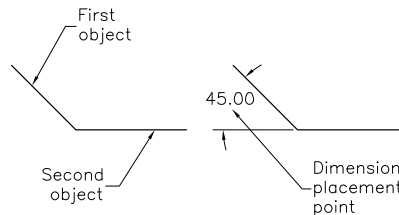


Figure 3-20 Minor angle dimension

Angular Dimensioning Using Three Points

You can also apply angular dimensions using three points. Remember that the three points should be selected in the clockwise or counterclockwise sequence. The points that can be used to apply the angular dimensions include the endpoints of lines or arcs, or the center points of arcs, circles, and ellipses. Figure 3-21 shows angular dimensioning using three points.

Angular Dimensioning of an Arc

You can use angular dimensions to dimension an arc. In case of arcs, the three points are the endpoints and the center point of the arc. Note that the points should be selected in the clockwise or counterclockwise sequence, but the center point should always be the second selection point. Figure 3-22 shows the angular dimensioning of an arc.

Diameter Dimensioning

Diameter dimensions are applied to dimension a circle or an arc to specify its diameter. In Autodesk Inventor, when you select a circle to dimension, the diameter dimension is applied to it by default. However, if you select an arc to dimension, the radius dimension is applied to it. You can also apply the diameter dimension to an arc by invoking the **Dimension** tool and selecting the arc. Now, right-click to display the shortcut menu, see Figure 3-23. Choose **Diameter** from this shortcut menu to apply the diameter dimension. Figure 3-24 shows a circle and an arc with diameter dimensions.

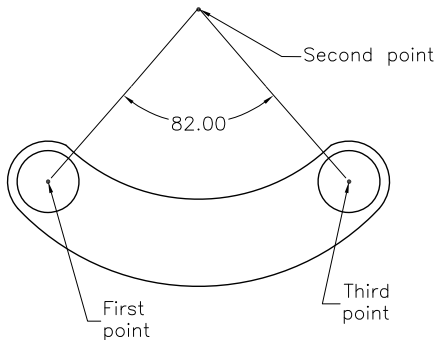


Figure 3-21 Angular dimensioning using three points

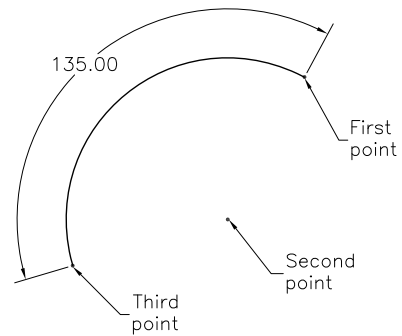


Figure 3-22 Angular dimensioning of an arc

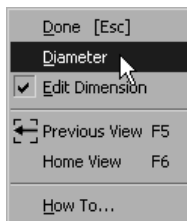


Figure 3-23 Shortcut menu to apply a diameter dimension to an arc

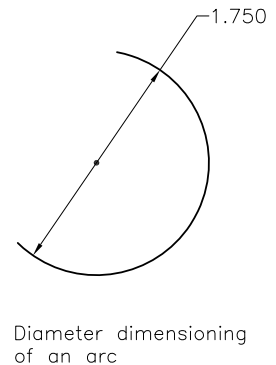
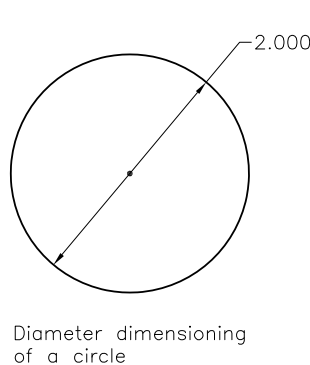


Figure 3-24 Diameter dimensioning of a circle and an arc

Radius Dimensioning

Radius dimensions are applied to dimension an arc or a circle to specify its radius. As mentioned earlier, by default, the circles will be assigned diameter dimensions and the arcs will be assigned radius dimensions. However, you can also apply the radius dimension to a circle. To do so, invoke the **DIMENSION** tool and then select the circle. Now, right-click to display the shortcut menu, as shown in Figure 3-25. Choose **RADIUS** from this menu to apply the radius dimension. Figure 3-26 shows an arc and a circle with radius dimensions.

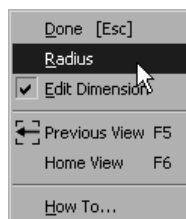


Figure 3-25 Shortcut menu to apply the radius dimension to a circle

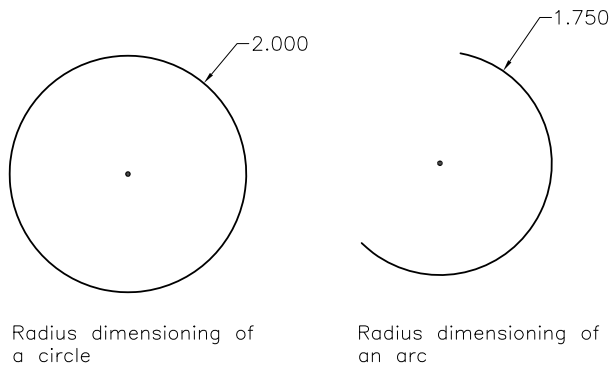


Figure 3-26 Radius dimensioning of a circle and an arc



Tip. After invoking the **Dimension** tool, as you move the cursor close to the sketched entities, a small symbol will be displayed close to the cursor. This symbol displays the type of dimension that will be applied. For example, if you select a line, the linear dimensioning or aligned dimensioning symbol will be displayed. If you move the cursor close to another line after selecting the first, the symbol of angular dimensioning will be displayed. These symbols help you in determining the type of dimensions that will be applied.

In Autodesk Inventor, the ellipses are dimensioned as half of the major and minor axes distances. To dimension an ellipse, invoke the **Dimension** tool and then select the ellipse. Now, if you move the cursor in the vertical direction, the axis of the ellipse along the X-axis will be dimensioned in terms of its half length. Similarly, if you move the cursor in the horizontal direction, the axis of the ellipse along the Y axis will be dimensioned equal to its half-length.

To distinguish whether the dimension applied to an arc or a circle is a radius or a diameter, try to locate the number of arrowheads in the dimension. If there are two arrowheads in the dimension and the dimension line is placed inside the circle or the arc, it is a diameter dimension. The radius dimension has one arrowhead and the dimension line is placed outside the circle or the arc.

Linear Diameter Dimensioning

Linear diameter dimensioning is used to dimension the sketches of the revolved components. The sketch for a revolved component is drawn using simple sketcher entities. For example, if you draw a rectangle and revolve, it will result in a cylinder. Now, if you dimension the rectangle using the linear dimensions, the same dimensions will be displayed when you generate the drawing views of the cylinder. Also, the same dimensions will be used while manufacturing the component. But these linear dimensions will result in a confusing situation in

manufacturing. This is because while manufacturing a revolved component, the dimensions have to be specified as the diameter of the revolved component. The linear dimensions will not be acceptable in manufacturing a revolved component. To resolve this problem, the sketches for the revolved features are dimensioned using the linear diameter dimensions. These dimensions display the distance between the two selected line segments as a diameter; that is, double the original length. For example, if the original dimension between two entities is 10 mm, the linear diameter dimension will display it as 20 mm. This is because when you revolve a rectangle with 10 mm width, the diameter of the resultant cylinder will be 20 mm. In this type of dimension, if you select two lines, the line selected first will act as the axis of revolution for the sketch and the line selected last will result in the outer surface of the revolved feature. It means the line selected last will be the one that will be dimensioned. But, if one of these lines is a centerline drawn by choosing the **Centerline** button from the **Format** panel of the **Sketch** tab, the centerline will be considered as the axis of revolution.

To apply linear diameter dimensions, invoke the **Dimension** tool; you will be prompted to select the first geometry to dimension. Select the first line; you will be prompted to select the second geometry to dimension. Select the second line with reference to which you want to apply the linear diameter dimensions. If the first line you selected is a centerline, the linear diameter dimension will be displayed. Else, right-click and choose **Linear Diameter** from the shortcut menu, see Figure 3-27. You will notice that the distance between the two lines is displayed as double the distance. Also, the dimension value is preceded by the \varnothing symbol, suggesting that it is a linear diameter dimension. Figures 3-28 and 3-29 show the use of linear diameter dimensioning.

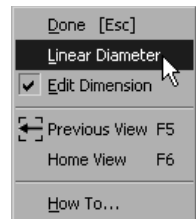


Figure 3-27 Choosing the *Linear Diameter* option

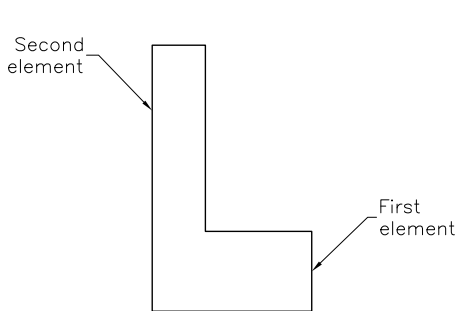


Figure 3-28 Selecting elements for linear diameter dimensions

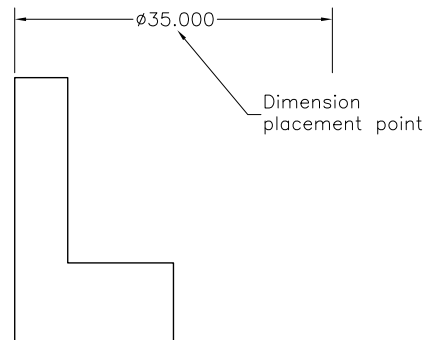


Figure 3-29 The linear diameter dimension

CREATING DRIVEN DIMENSIONS

Ribbon: Sketch > Format > Driven Dimension



This toggle button is used to switch between the driven dimension and the sketch (driving) dimension. A dimension is called as a sketch (driving) dimension, if it forces

an entity to change its length and orientation. A driven dimension is the one whose value depends on the value of the sketch (driving) dimension. The driven dimensions are enclosed in a parenthesis that displays the current value of the sketched geometry and this value cannot be modified. If you change the value of the sketch (driving) dimension, the value of the driven dimension will change automatically, as shown in Figures 3-30 and 3-31. All dimensions applied after choosing the **Driven Dimension** button will be the driven dimensions. To convert sketch (driving) dimensions into driven dimensions, select the required sketch (driving) dimension and choose the **Driven Dimension** button from the **Format** panel of the **Sketch** tab.

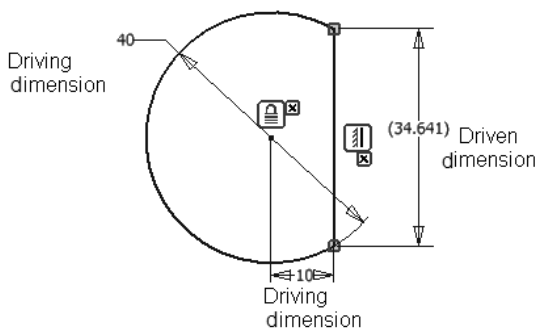


Figure 3-30 Driving dimension and driven dimension in a sketch

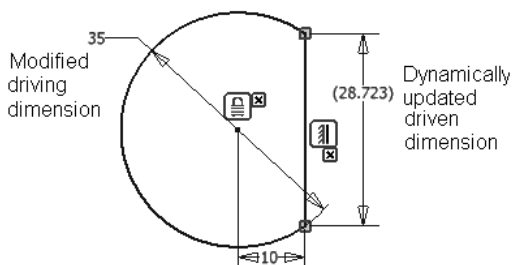


Figure 3-31 Modified driving dimension and updated driven dimension

UNDERSTANDING THE CONCEPT OF FULLY CONSTRAINED SKETCHES

A fully constrained sketch is the one whose all entities are completely constrained to their surroundings using constraints and dimensions. In a fully constrained sketch, all degrees of freedom of the sketch are constrained. A fully constrained sketch cannot change its size, location, or orientation unexpectedly. Whenever you draw a sketched entity, it will be black in color. If you add dimensions and constraints to fully constrain it, the entities will turn blue. There is one more method to understand whether the sketched entities are fully constrained or not. In this method, you need to right-click in the graphic window and choose the **Show All Degrees of Freedom** option from the shortcut menu; the entities will display the available degrees of freedom such as horizontal, vertical, angular, or rotational. Note that while creating the base sketch in Autodesk Inventor, you need to dimension it with respect to a fixed point in order to fully constrain it. Therefore, you need to use some extra steps to fully constrain the sketch. These steps are given next.

1. Draw a sketch point at the origin. You can use the **Inventor Precise Input** toolbar to ensure that the point is placed exactly at the origin.
2. Apply the **Fix** constraint to the point.
3. Use this point to dimension the original sketch. You can add horizontal and vertical dimensions to the sketch from this point. You can also add a **Coincident** constraint between the point and the endpoints of one of the entities in the sketch.

MEASURING SKETCHED ENTITIES

Autodesk Inventor allows you to measure various parameters of the sketched entities. The parameters that you can measure are distances, angles, loops, and area. Measuring these parameters is discussed next.

Measuring Distances

Ribbon:	Tools > Measure > Distance
Shortcut Menu:	Measure > Measure Distance

Autodesk Inventor allows you to measure the length of a line segment, radius of an arc, diameter of a circle, minimum distance between two entities, or coordinates of a point. All these distances can be measured by using the **Distance** tool from the **Measure** panel of the **Tools** tab. On invoking this tool, the **Measure Distance** dialog box will be displayed and you will be prompted to select the first item. The **Measure Distance** dialog box is modified depending upon the type of entities selected to be measured. The methods of measuring distances between various entities are discussed next.

Measuring the Length of a Line Segment

When you invoke the **Distance** tool, the **Measure Distance** dialog box will be displayed and you will be prompted to select the first entity. If you select a line segment at this point, the **Measure Distance** dialog box will be changed to the **Length** dialog box and the length of the selected line segment will be displayed in this dialog box, see Figure 3-32.

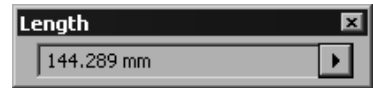


Figure 3-32 The **Length** dialog box displaying the length of a line segment



Tip. To restart measuring the distances, right-click to display the shortcut menu and choose **Restart**; you will be prompted to select the first element to be measured.

Measuring the Distance between a Point and a Line Segment

To measure the distance between a point and a line segment, invoke the **Distance** tool and then select the point. The **Measure Distance** dialog box is modified to **Position** dialog box that shows the X, Y, and Z coordinates of the point and you will be prompted to select the next entity. Select the line; the **Position** dialog box will be changed to the **Minimum Distance** dialog box. This dialog box will display the minimum distance between the point and the line, and the length of the line, see Figure 3-33.

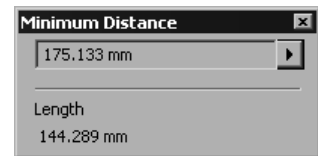


Figure 3-33 The **Minimum Distance** dialog box displaying the distance between the lines

Measuring Coordinates of a Point

To measure the coordinates of a point with respect to the current coordinate system, invoke the **Distance** tool; you will be prompted to select the first element. Select the point whose

coordinates you want to know. The selectable points include the endpoints of lines, arcs, or splines, center point of arcs, circles, or ellipses, or hole centers. If you select a hole center or the center point, the **Measure Distance** dialog box will be changed to the **Position** dialog box and the X, Y, and Z coordinates of the selected point with respect to the current coordinate system will be displayed, see Figure 3-34. However, if you select an endpoint, the coordinates will be specified in the **Measure Distance** dialog box.

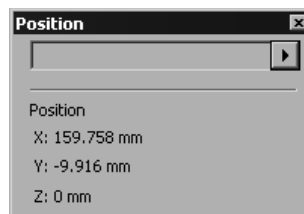


Figure 3-34 The **Position** dialog box displaying the coordinates of a point

Measuring the Distance between Two Points

To measure the distance between two points, invoke the **Distance** tool and then select the first point; the coordinates of the selected point will be displayed in the **Position** dialog box. You will be prompted to select the second element. Select the second point; the **Position** dialog box will be changed to the **Minimum Distance** dialog box. This dialog box will display the distance between the two points. This dialog box will also display the coordinates of the second point. You will also notice the **Delta X**, **Delta Y**, and **Delta Z** values in this dialog box, see Figure 3-35. These values are the distances between the two selected points along the X, Y, and Z axes. Note that if you move the cursor after selecting the second point, the **Position** dialog box will be replaced by the **Measure Distance** dialog box.

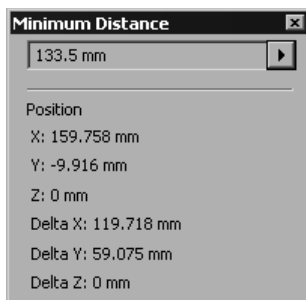


Figure 3-35 The **Minimum Distance** dialog box



Tip. You would have noticed that the Z coordinates or the Z distances are zero at all places. This is because by default, when you start a new drawing, the sketches are drawn in the XY plane. You can also draw the sketches on other planes. You will learn more about these sketching planes in the later chapters.

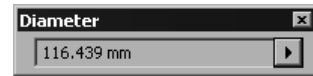
Measuring the Radius of an Arc or the Diameter of a Circle

You can also measure the radius of an arc or the diameter of a circle using the **Distance** tool. When you invoke this tool, the **Measure Distance** dialog box will be displayed and you will be prompted to select the first item. If you select an arc, this dialog box will be momentarily changed to the **Radius** dialog box and will display the radius of the arc, see Figure 3-36. If

you select a circle, this toolbar will be momentarily changed to the **Diameter** dialog box and will display the diameter of the circle, see Figure 3-37. Note that when you select an arc or a circle, you are not prompted to select the second element. This is because you cannot calculate any value other than their radius or diameter.



*Figure 3-36 The **Radius** dialog box displaying the radius of the arc*



*Figure 3-37 The **Diameter** dialog box displaying the diameter of the circle*

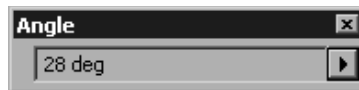
Measuring Angles

Ribbon:	Tools > Measure > Angle
Shortcut Menu:	Measure > Measure Angle

To measure an angle, right-click in the drawing window and choose **Measure > Measure Angle** from the shortcut menu; the **Measure Angle** dialog box will be displayed. Alternatively, choose the **Angle** button from the **Measure** panel of the **Inspect** tab. This tool is used to measure the angle between two line segments or among three points. Both these methods for measuring angles are discussed next.

Measuring the Angle between Two lines

To measure the angle between two lines, invoke the **Angle** tool; the **Measure Angle** dialog box will be displayed and you will be prompted to select the first item. Select the first line; you will be prompted to select the second line. The **Measure Angle** dialog box will change momentarily to the **Angle** dialog box and the angle between the selected line segments will be displayed, see Figure 3-38.



*Figure 3-38 The **Angle** dialog box displaying the angle between two lines*

Measuring the Angle Using Three Points

You can also measure the angle using three points. When you invoke the **Angle** tool, you will be prompted to select the first item. Select the first point; you will be prompted to select the next point. After you select the second point, you will again be prompted to select the next point. Select the third point. Once you have selected the three points, Autodesk Inventor draws imaginary lines between the first and second points as well as between the second and third points. The angle between these two imaginary lines will be measured and displayed in the dialog box, as shown in Figures 3-39 and 3-40.

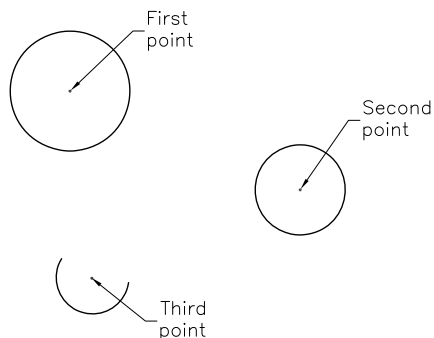


Figure 3-39 Selecting three points

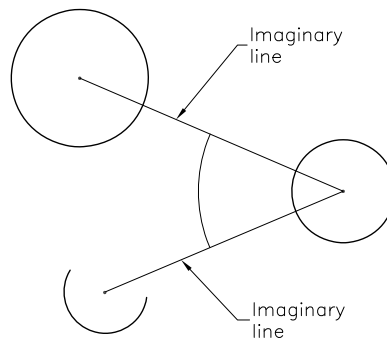


Figure 3-40 Angle between imaginary lines



Tip. Autodesk Inventor allows you to switch from one measuring tool to another. This is done using the flyout that is displayed on choosing the arrow on the right of the dialog box of any measuring tools. When you choose this arrow, the flyout will be displayed with the options for invoking other measuring tools.

Measuring Loops

Ribbon: Tools > Measure > Loop
Shortcut Menu: Measure > Measure Loop

Autodesk Inventor allows you to measure closed loops. To measure closed loops, right-click in the drawing window and choose **Measure > Measure Loop** from the shortcut menu; the **Measure Loop** dialog box will be displayed. Alternatively, choose the **Loop** button from the **Measure** tab; you will be prompted to select a face or a loop. Select the loop to be measured; the **Measure Loop** dialog box will be momentarily changed to the **Loop Length** dialog box and the measurement will be displayed in it. Figure 3-41 shows the **Measure Loop** dialog box with the measurement of a loop.



Figure 3-41 The **Measure Loop** dialog box

Measuring the Area

Ribbon: Tools > Measure > Area
Shortcut Menu: Measure > Measure Area

To measure the area of closed loops, right-click in the drawing window and choose **Measure > Measure Area** from the shortcut menu; the **Measure Area** dialog box will be displayed and you will be prompted to select a face or a loop. Select the closed loop to measure the area; the **Measure Area** dialog box will change momentarily to the **Area** dialog box and the area of the loop will be displayed in it. Figure 3-42 shows the **Area** dialog box with the area of a closed loop.

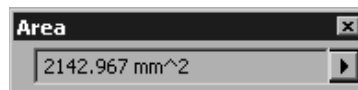


Figure 3-42 The **Area** dialog box



Tip. You can also measure the loop or the area defined by a face of an existing feature. You will learn more about features in the later chapters.

Adding Linear Measurements

Shortcut Menu: Measure > Measure Distance > Add to Accumulate

You can calculate the total measurement of several linear measurements by adding their values. To do so, invoke the **Distance** or **Angle** tool. Next, select the geometry or the distance to be measured; the measurement will be displayed in the **Measure Distance** dialog box. Next, click the arrow on right side of the display box; a flyout will be displayed. Choose the **Add to Accumulate** option from the flyout and again choose the same arrow; the same flyout will be displayed. Choose the **Restart** option from the flyout. Next, choose another measurement and follow the same procedure till you add all the desired measurements. Then click on the arrow and choose the **Display Accumulate** option from the flyout; the sum of the measurements will be displayed in the dialog box.

Clearing Accumulated Dimensions

Shortcut Menu: Measure > Measure Distance > Clear Accumulate

On choosing this option, you can clear all the accumulated measurements and reset the sum to zero. This option is located below the **Add to Accumulate** option.

Evaluating Region Properties

Ribbon: Tools > Measure > Region
Shortcut Menu: Measure > Region Properties

This tool is used to evaluate the properties of the closed sketch loop such as area, perimeter, and display the region properties of the sketch such as Area and Moment of Inertia by taking measurements from the sketch coordinate system. To invoke this tool, right-click in the drawing window and choose **Measure > Region Properties** from the shortcut menu; the **Region Properties** dialog box will be displayed, as shown in Figure 3-43. Alternatively, invoke the **Region Properties** tool by choosing the **Region** button from the **Measure** panel of the **Tools** tab. The options in this dialog box are discussed next.

Selections

When you invoke the **Region Properties** dialog box, this option is chosen by default and you will be prompted to select one or more closed sketch loops. Select one or more closed sketch loops from the drawing window.

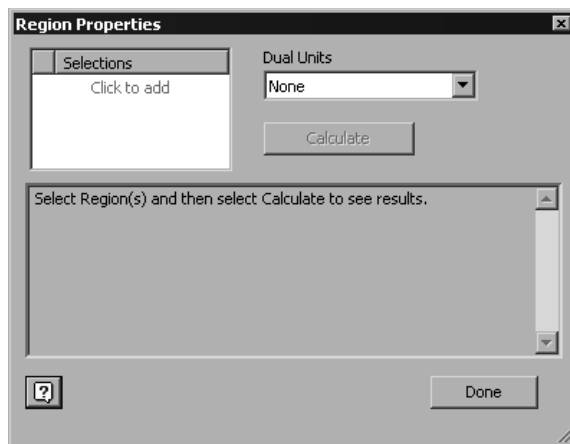


Figure 3-43 The Region Properties dialog box

Dual Units

You can select the required unit of measurement from this drop-down list to display the results of measurements in the selected unit. You can view the results in two different units.

Calculate

After setting the options in the **Selections** and the **Dual Units** area, choose the **Calculate** button; the results will be displayed in the display box. In case you add or remove a closed loop in the **Selections** area or change the unit in the **Dual Units** drop-down list, the recalculation will occur and the updated results will be displayed in the display box.

TUTORIALS

From this chapter onward, you will use the parametric nature of Autodesk Inventor for drawing and dimensioning sketches. The following tutorials will explain the method of drawing sketches with some arbitrary dimensions and then driving them to the dimension values required in the model.

Tutorial 1

In this tutorial, you will draw the sketch shown in Figure 3-44. This sketch is same as the one drawn in Tutorial 2 of Chapter 2. In this tutorial, you will not use the **Inventor Precise Input** toolbar while drawing the initial sketch. After drawing the sketch, you will add the required constraints and then dimension it. Also, you will place a point at the origin and fix it at that location. Then you will dimension the sketch as well as fully constrain the sketch using this point. **(Expected time: 30 min)**

The following steps are required to complete this tutorial:

- a. Start a new metric standard part file.
- b. Draw the initial sketch using the **Line** and **Two point rectangle** tools, refer to Figure 3-45.

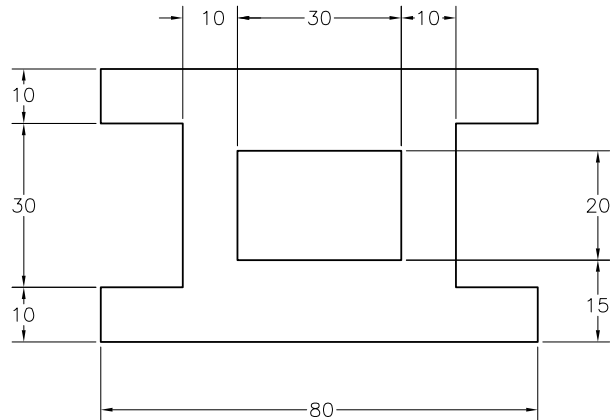


Figure 3-44 Dimensioned sketch for Tutorial 1

- c. Add required constraints and dimensions to complete the sketch, refer to Figure 3-47.
- d. Place a sketch point at the origin(0,0) and add the **Fix** constraint to it.
- e. Dimension the sketch using this point to fully constrain it, refer to Figure 3-48.
- f. Save the sketch with the name *Tutorial1.ipt* and then close the file.

Starting Autodesk Inventor

1. Start Autodesk Inventor by double-clicking on its shortcut icon on the desktop of your computer or by using the **Start** menu.
2. Choose the **New** button from the **Quick Access Toolbar** and start a new metric standard part file using the **Metric** tab of the **New File** dialog box.

Drawing the Initial Sketch

1. Using the **Line** tool and the **Two point rectangle** tool, draw the required sketch similar to the one shown in Figure 3-44. You do not need to draw the sketch to the exact length. Use the temporary tracking option for drawing the sketch. For your reference, all lines in the sketch are numbered, see Figure 3-45.

Note that in this sketch, the display of the X and Y axes is turned off.

Adding Constraints to the Sketch

It is evident from Figure 3-45 that some of the lines need to be of the same length. For example, lines 1 and 7, lines 2 and 6, lines 8 and 12, and so on need to be of the same length. You can do so by using two options. In the first option, you can assign dimensions to all these lines. However, this will increase the number of dimensions in the sketch. In the second option, you can apply constraints that will force the lines to maintain an equal length.

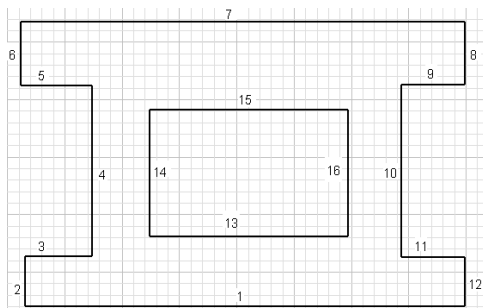


Figure 3-45 Initial sketch drawn using the sketching tools

In this case, you can apply the **Equal** constraint to all lines that have same length. This constraint will relate the length of one of the lines with respect to the other. Now, if you dimension any one of the related lines, all other lines related to it are forced to acquire the same dimension value. The **Equal** constraint is applied in pairs.

1. Choose the **Equal** button from the **Constrain** panel of the **Sketch** tab to invoke the **Equal** constraint.



When you invoke this constraint, you are prompted to select the first line, circle, or arc.

2. Select line 2; the color of this line is changed to blue and you are prompted to select the second line, circle, or arc. Select line 6; the **Equal** constraint is applied to lines 2 and 6. Again, you are prompted to select the first line, circle, or arc. Select line 6 as the first line and then line 8 as the second line.

If the Autodesk Inventor warning message box is displayed while applying any of these constraints, choose **Cancel** to exit that box.

3. Similarly, select lines 8 and 12, 1 and 7, 3 and 5, 5 and 9, 9 and 11, 13 and 15, and then lines 14 and 16. The **Equal** constraint is applied to all these pairs of lines. Next, right-click in the drawing window, and then choose **Done** from the shortcut menu.
4. Choose the **Horizontal Constraints** button from the **Constrain** panel of the **Sketch** tab; you are prompted to select a line, ellipse axis, or first point.
5. Select line 1; the **Horizontal** constraint is applied to the line.
6. Similarly, apply the **Horizontal** constraint to lines 3, 5, 7, 9, 11, 13, and 15.
7. Choose the **Vertical Constraint** button from the **Constrain** panel of the **Sketch** tab; you are prompted to select a line, ellipse axis, or first point.
8. Select line 2; the **Vertical** constraint is applied to the line.



9. Similarly, apply the **Vertical** constraint to lines 4, 6, 8, 10, 12, 14, and 16.

Dimensioning the Sketch

Once all required constraints are applied to the sketch, you can dimension it. As mentioned earlier, when you add dimensions to a sketch and modify their values, an entity is forced to the specified dimension values.

1. Choose the **Dimension** button from the **Constrain** panel of the **Sketch** tab; you are prompted to select the geometry to be dimensioned. Select line 1.



As soon as you move the cursor close to line 1, it turns red and a small symbol is displayed, suggesting that a linear dimension is applied to this line. It is important to modify the value of the dimension after it is placed so that geometries are driven to the values that you require. Therefore, after selecting line 1, right-click to display the shortcut menu. In this menu, choose **Edit Dimension**. If it is already chosen, press ESC once. This will make sure that the **Edit Dimension** toolbar is displayed when you place the dimension. This toolbar allows you to modify the dimension value.

2. Place the dimension below line 1; the **Edit Dimension** toolbar is displayed. Enter **80** as the length of line 1 in this toolbar and then choose the check mark on the right of this toolbar.

You will notice that the length of the line is modified to 80 units. Also, the length of line 7 is also modified because of the **Equal** constraint (refer to Figure 3-47).

3. As you are still in the **Dimension** tool, you are prompted again to select the geometry to dimension. Select line 2 and place the dimension on the left of this line; the **Edit Dimension** toolbar is displayed. Change the length of this line to **10** in this toolbar.

You will notice that the length of lines 6, 8, and 12 is also forced to 10 units. This is because the **Equal** constraint is applied to all these lines.

4. Select line 4 and place it along the previous dimension. Modify the dimension value to **30** in the **Edit Dimension** toolbar. Notice that the length of line 10 is also modified.
5. Select line 16 and place the dimension outside the sketch on the right. Modify the dimension value in the **Edit Dimension** toolbar to **20**.
6. Select line 15 and place the dimension outside the sketch on the top. Modify the dimension value to **30** in the **Edit Dimension** toolbar.
7. Now, to dimension the distance between lines 4 and 14, select them one by one. Place the dimension outside the sketch on the top and then change the dimension value to **10** in the **Edit Dimension** toolbar.
8. Similarly, select lines 16 and 10 to dimension the distance between these two lines and place the dimension outside the sketch on the top. Change the dimension value to **10**

in the **Edit Dimension** toolbar. You will notice that the length of lines 5, 9, 3, and 11 is automatically adjusted due to the **Equal** constraint.

9. To locate the inner rectangle vertically from the outer loop, select lines 1 and 13, and then place the dimension on the right of the sketch. Next, modify the dimension value in the **Edit Dimension** toolbar to **15**.

With this, you have applied all required constraints and dimensions to the sketch. Now, the sketch is ready to be converted into a feature. If you try to add more constraints or dimensions to this sketch, Autodesk Inventor will display an error message box, informing that adding this dimension or constraint will over-constrain the sketch, see Figure 3-46. If you still want this dimension to be displayed, choose the **Accept** button from this message box. The dimension will be added as a driven dimension. A driven dimension is placed inside parentheses and is not used during the manufacturing process. This dimension is used only for reference. Note that you cannot edit the value of a driven dimension.

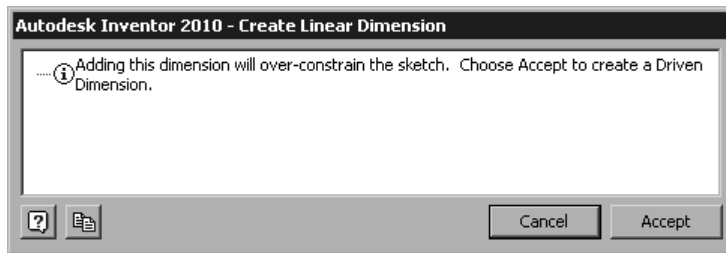


Figure 3-46 The Autodesk Inventor - 2010 message box

10. The sketch, after applying all dimensions and constraints, should look similar to the one shown in Figure 3-47.

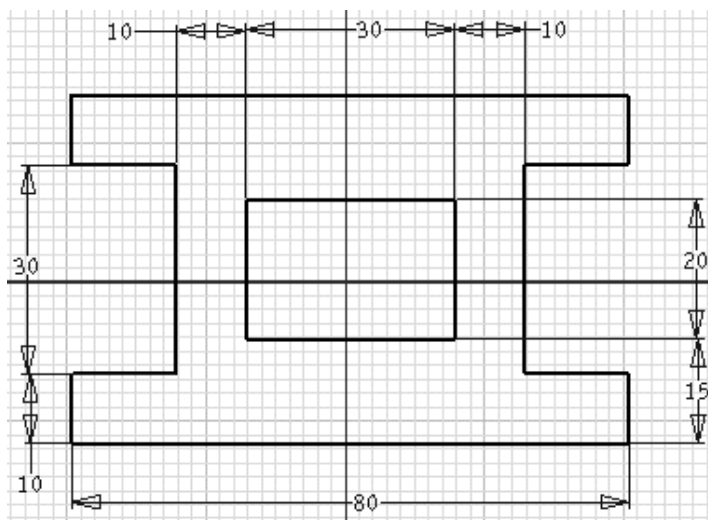


Figure 3-47 Sketch after adding dimensions

Even after adding all dimensions, the color of entities in the sketch is still black. This is because the sketch is not fully constrained. As mentioned in the tutorial description, you need to place a sketch point at the origin and then use it to fully constrain the sketch.



11. Place a sketch point at the origin using the **Inventor Precise Input** toolbar.
12. Choose the **Fix** button from the **Constrain** panel of the **Sketch** tab; you are prompted to select a curve or a point to be fixed. 
13. Select the sketch point that you placed at the origin. The point is fixed at the origin and now you can use it to fully constrain the initial sketch.
14. Choose the **Coincident Constraint** button from the **Constrain** panel of the **Sketch** tab; you are prompted to select the first curve or point. 
15. Select the intersection point of lines 1 and 2, which is the lower left vertex of the sketch. You are prompted to select the second curve or point.
16. Select the sketch point placed at the origin. The entire sketch shifts itself such that the lower left vertex of the sketch is now at the origin. In spite of its shift, the sketch is not completely visible in the drawing window.
17. Choose the **Zoom All** button from the **Navigation** bar to fit the sketch into the drawing window. You will notice that all entities in the sketch turn blue, indicating that the sketch is fully constrained. Next, press ESC to exit the **Coincident Constraint** tool.

Figure 3-48 shows the fully constrained sketch for Tutorial 1.

Saving the Sketch

1. Choose the **Finish Sketch** button from the **Exit** panel of the **Sketch** tab to exit the sketching environment.
2. Choose the **Save** button from the **Quick Access Toolbar** or the **Application Menu** and save this sketch with the name *Tutorial1* at the location given below:

C:\Inventor_2010\c03

3. Choose **Close > Close** from the **Application Menu** to close the file.

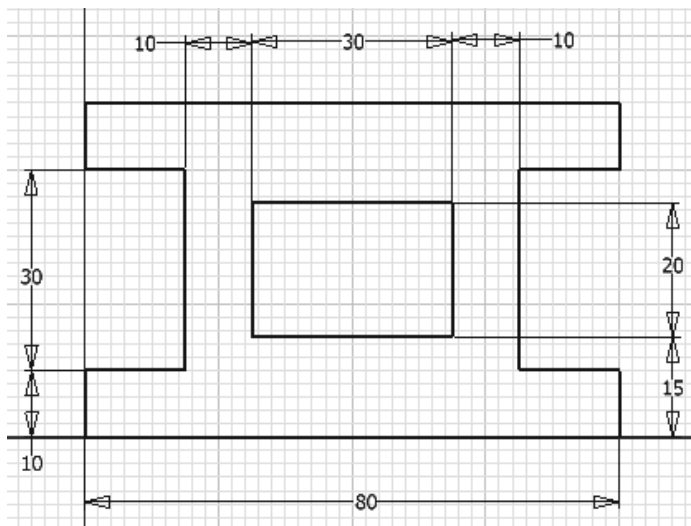


Figure 3-48 Fully constrained sketch for Tutorial 1

Tutorial 2

In this tutorial, you will draw the sketch shown in Figure 3-49. This sketch is the same as the one drawn in Tutorial 4 of Chapter 2. In this tutorial, you will not use the **Inventor Precise Input** toolbar to draw the initial sketch. After drawing it, you will apply the required constraints and dimensions to fully constrain it. **(Expected time: 30 min)**

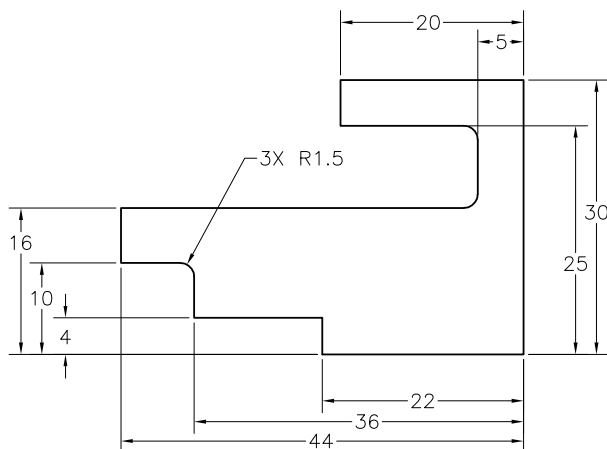


Figure 3-49 Sketch for Tutorial 2

The following steps are required to complete this tutorial:

- Start a new metric standard part file and draw the initial sketch using the **Line** tool, refer to Figure 3-50.

- b. Place a point at the origin and fix it using the **Fix** constraint.
- c. Add linear diameter dimensions to the sketch by using the **Dimension** tool.
- d. Apply the **Coincident Constraint** between the fixed sketch point and the lower left vertex of the sketch to make it a fully constrained sketch, refer to Figure 3-51.
- e. Add fillets and then save the sketch with the name *Tutorial2.ipt* and close the file.

Starting a New File

1. Choose the **New** button from the **Quick Access Toolbar** and start a new metric standard part file using the **Metric** tab of the **New File** dialog box.

Drawing the Initial Sketch

1. Draw the initial sketch, as shown in Figure 3-50, using the **Line** tool. The lines in the sketch are numbered for your reference.

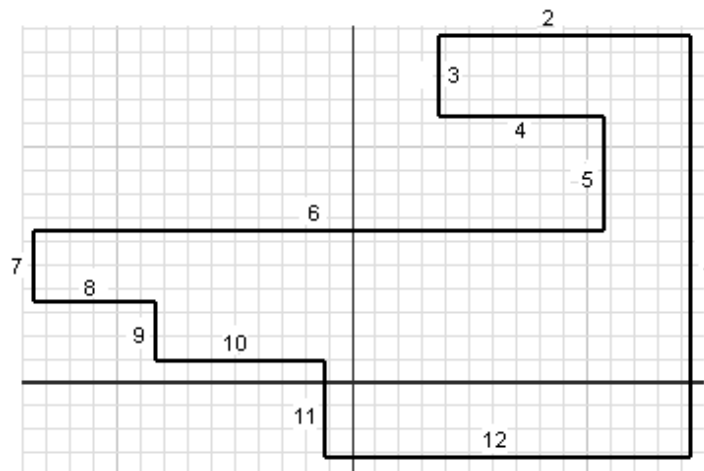


Figure 3-50 Numbering the lines in the sketch

2. Place the sketched point at the origin using the **Inventor Precise Input** toolbar.

Dimensioning and Constraining the Sketch

The dimensions shown in Figure 3-49 are linear dimensions. As the sketch is for a revolved feature, you need to add linear diameter dimensions to it. It is recommended to first apply all dimensions and then add fillets to the sketch. This is because a sketch generally changes its size after dimensioning. Before proceeding with adding dimensions to a revolved section, it is important for you to determine which line segment of the sketch will act as the axis for revolving the sketch. If you refer to Figure 2-46 in Chapter 2, you will notice that line 12 acts as the axis for revolving the sketch for this model. Therefore, while applying linear diameter dimensions, line 12 should be selected first.

1. Choose the **Dimension** button from the **Constrain** panel of the **Sketch** tab; you are prompted to select the geometry to be dimensioned. Right-click to display the



shortcut menu, and then choose **Edit Dimension** from it, if it is not already chosen. If it is already chosen, press the ESC key once to exit the shortcut menu.

2. Select line 12; you are prompted again to select the geometry to be dimensioned. Select line 10 and then right-click; a shortcut menu is displayed. In this menu, choose **Linear Diameter**.

You will notice that the dimension is displayed as double of its actual length. Also, the dimension value is preceded by the Ø symbol, indicating that it is a linear diameter dimension.

3. Place the dimension on the left of the sketch; the **Edit Dimension** toolbar is displayed.
4. Figure 3-49 shows the value to be specified as 4. Because the linear diameter dimensions are placed as the double of the original length, enter **8** in the **Edit Dimension** toolbar. The vertical distance between lines 12 and 10 is automatically adjusted to adjust the value entered.
5. As the **Dimension** tool is still active, you are prompted again to select the geometry to be dimensioned. Select line 12 and then line 8 and then right-click; a shortcut menu is displayed. Choose **Linear Diameter** from it. The linear dimension is changed to the linear diameter dimension. Place the dimension on the left of the previous dimension. Next, modify its value in the **Edit Dimension** toolbar to **20**.
6. Select lines 12 and 6. Right-click to display the shortcut menu, and then choose **Linear Diameter** from it. Place the dimension on the left of the previous dimension and change the dimension value in the **Edit Dimension** toolbar to **32**.



Tip. Autodesk Inventor allows you to invoke the drawing display options even when a sketching environment tool is active. This is done using a combination of hot keys and the left mouse button. For example, if the **Dimension** tool is active, you can use the **Pan** option by holding the F2 key and then pressing the left mouse button and dragging the cursor. Similarly, you can dynamically zoom in and out of the sketch by holding the F3 key and then pressing the left mouse button and dragging.

7. Select lines 12 and 4, and then right-click; a shortcut menu is displayed. In this shortcut menu, choose **Linear Diameter**. Place the dimension on the right of the sketch and change the value in the **Edit Dimension** toolbar to **50**.
8. Select lines 12 and 2, and then right-click to display the shortcut menu. In this menu, choose **Linear Diameter**. Place the dimension on the right of the previous dimension and change its value in the **Edit Dimension** toolbar to **60**.

With this, you have applied all required linear diameter dimensions to the sketch. Now, you need to add linear dimensions to the sketch



9. Select lines 1 and 5, and then place the dimension above the sketch. Modify its value in the **Edit Dimension** toolbar to **5**.



Tip. Sometimes while dimensioning a sketch, some existing dimensions move from the location where they have been placed. In this case, you need to exit the **Dimension** tool and then drag the existing dimensions back to their original locations. To continue dimensioning, invoke the **Dimension** tool again.

10. Select line 2 and then place the dimension above the previous dimension. Modify its value in the **Edit Dimension** toolbar to **20**.
11. Select line 12 and then place the dimension below the sketch. Modify its value in the **Edit Dimension** toolbar to **22**.
12. Select lines 1 and 9, and then place the dimension below the previous dimension. Modify its value in the **Edit Dimension** toolbar to **36**.
13. Select lines 1 and 7, and then place the dimension below the previous dimension. Modify its value in the **Edit Dimension** toolbar to **44**.

With this, all dimensions are added to the sketch. However, entities in the sketch are still displayed in black, indicating that the sketch is not fully constrained. Therefore, you need to add more dimensions or constraints. In this sketch, first you will add the **Fix** constraint to the sketched point placed at the origin and then add the **Coincident Constraint** to the sketched point and the intersection point of lines 11 and 12.

14. Invoke the **Point** tool and place the point at the origin.
15. Invoke the **Fix** constraint from the **Constrain** panel of the **Sketch** tab and select the sketch point placed at the origin to fix it at the origin. 
16. Invoke the **Coincident Constraint** tool; you are prompted to select the first curve or point. Select the intersection point of lines 11 and 12, which is the lower left vertex of the sketch; you are prompted to select the second curve or point. 
17. Select the sketched point placed at the origin; the entire sketch shifts from its original location and is relocated such that the lower left vertex of the sketch now lies at the origin.
18. Apply the **Vertical Constraint** to the vertical line drawn on the right of the sketch; all entities in the sketch are displayed in blue, indicating that the sketch is fully constrained.
19. Choose the **Zoom All** button from the **Navigation Bar** to fit the sketch into the drawing window. The fully constrained sketch, after adding all dimensions, is shown in Figure 3-51.

Adding Fillets to the Sketch

After dimensioning the sketch, you need to add fillets to it.

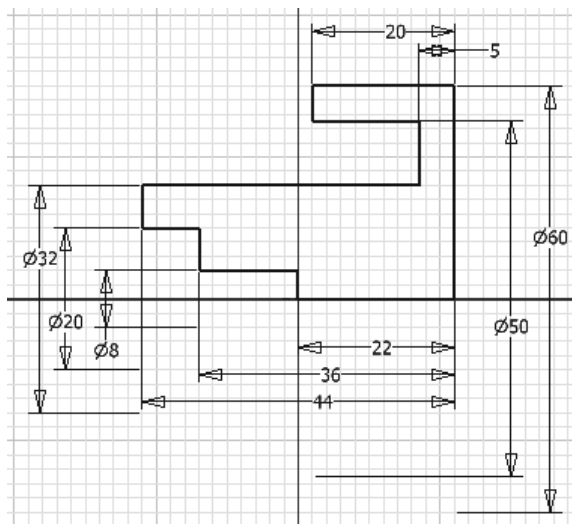


Figure 3-51 Fully constrained sketch for Tutorial 2

1. Choose the **Fillet** button from the **Draw** panel of the **Sketch** tab; the **2D Fillet** dialog box is displayed. In this dialog box, set the value of fillet to **1.5**. Now, select lines 8 and 9; the fillet is automatically added between these two lines and the fillet dimension is displayed.
2. Similarly, select lines 5 and 6 as well as lines 4 and 5 to add fillets between these lines. Exit the **2D Fillet** dialog box. The final sketch, after adding fillets, is shown in Figure 3-52.

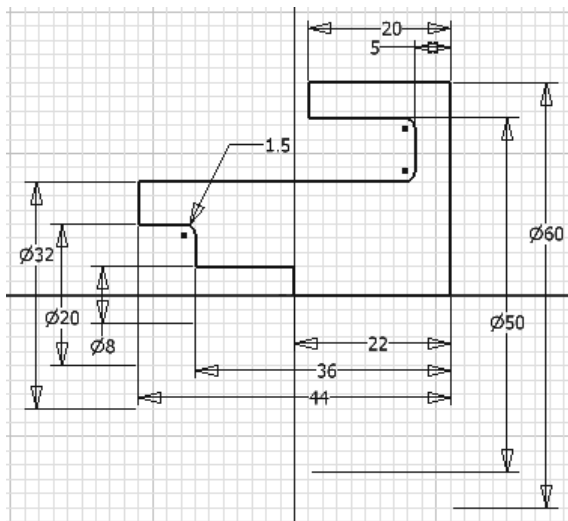


Figure 3-52 Fully dimensioned sketch after adding fillets



Note

To modify the radius of the fillet, double-click on it; the **Edit Dimension** toolbar is displayed. Modify the value of the fillet in this toolbar.

Saving the Sketch

1. Choose the **Finish** button from the **Exit** panel of the **Sketch** tab to exit the sketching environment.
2. Save this sketch with the name *Tutorial2* at the location *C:\Inventor_2010\c03*.
3. Choose **Close > Close** from the **Application Menu** to close the file.

Tutorial 3

In this tutorial, you will draw the sketch for the model shown in Figure 3-53. After drawing the sketch, you will add the required constraints and then dimension it. The basic dimensioned sketch required for this model is shown in Figure 3-54. The solid model shown in Figure 3-53 is only for your reference. **(Expected time: 30 min)**

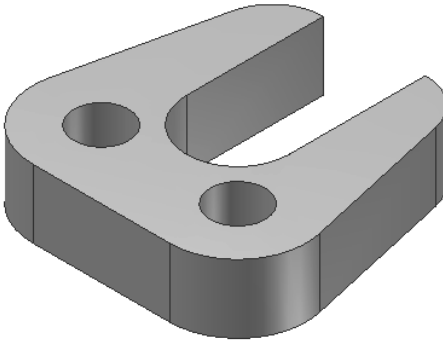


Figure 3-53 Model for Tutorial 3

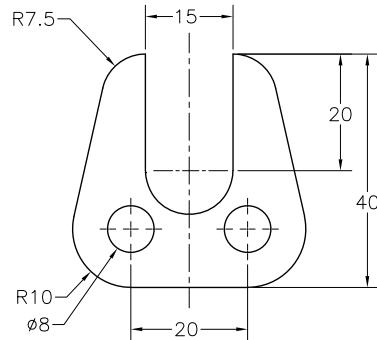


Figure 3-54 Dimensioned sketch for the model

The sketch shown in Figure 3-54 is the combination of multiple closed loops: the outer loop and inner circles. As the number of loops increases, so does the complexity of the sketch. This is because the number of constraints and dimensions in the sketch increases in the case of multiple loops. Now, to draw sketches without using the **Inventor Precise Input** toolbar, it is recommended that you first draw the outer loop of the sketch and then add constraints and dimensions to it. This is because once the outer loop is constrained and dimensioned, the inner circles can be constrained easily and dimensioned with reference to the outer loop.

The following steps are required to complete this tutorial:

- a. Start a new metric template and draw the outer loop of the sketch, refer to Figure 3-55.
- b. Add required dimensions and constraints to the outer loop, refer to Figure 3-57.
- c. Draw inner circles and add constraints and dimensions to them, refer to Figure 3-58.
- d. Finally, save the sketch with the name *Tutorial3.ipt* and close the file.

Starting a New File

1. Choose the **New** button from the **Quick Access Toolbar** and start a new metric standard part file using the **Metric** tab of the **New File** dialog box.

Drawing the Outer Loop

1. Using the **Line** tool, draw the profile, as shown in Figure 3-55.

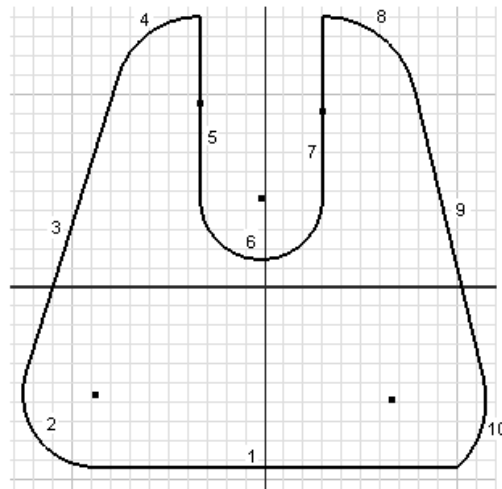



Figure 3-55 Profile with numbered geometries

You can use the option of drawing the tangent arcs using the **Line** tool for creating this sketch. This can be done by pressing the left mouse button and then dragging in the required direction (refer to Tutorial 3 of Chapter 2 to learn more about drawing this type of arc.)


For your reference, all geometries in the sketch are numbered. You will draw inner holes in the sketch after dimensioning the outer loop.

Adding Constraints to Sketched Entities

As evident from Figure 3-55, some of the constraints such as tangent and equal are missing in the sketch. Therefore, you need to manually add these constraints to the sketch. You can view the constraints applied on various geometries using the **Show Constraints** tool.




1. In Figure 3-55, the **Tangent** constraint is missing between line 1 and arc 10. To add this constraint, choose the **Tangent** button from the **Constrain** panel of the **Sketch** tab; you are prompted to select the first curve. Select arc 10 and then select line 1 as the second curve. Similarly, add this constraint to all places in the sketch where it is missing. 

The geometries 5 and 7, and 3 and 9 are lines that must be of equal length. Also, the geometries 2 and 10, and 4 and 8 are arcs that must be of equal radii. Therefore, you need to add the **Equal** constraint between the respective pairs of all these geometries.

2. Choose the **Equal** button from the **Constrain** panel of the **Sketch** tab. 
3. Select line 5 as the first line and then line 7 as the second line to apply the **Equal** constraint to them. Autodesk Inventor prompts you again to select the first entity. Select line 3 and then line 9 to apply the **Equal** constraint to these lines.

4. You are prompted to select the first entity again. Select arc 2 and then arc 10 to apply the **Equal** constraint to these arcs.

Applying this constraint to arcs or circles forces their radii or diameters to be equal.

5. Similarly, apply the **Equal** constraint to arcs 4 and 8.
6. Apply the **Coincident Constraint** between the center points of arc 4 and line 5, and the center points of arc 8 and line 7, if it is not applied automatically. 
7. Invoke the **Point** tool from the **Draw** panel of the **Sketch** tab and place the point at the origin.
8. Choose the **Fix** button from the **Constrain** panel of the **Sketch** tab and then select the sketched point; the point is fixed at the origin. 
9. Next, choose the **Coincident Constraint** button from the **Constrain** panel of the **Sketch** tab; you are prompted to select the first curve or point. 
10. Select the sketched point; you are prompted to select the second curve or point.
11. Select the center point of arc 6; the entire sketch moves to make the sketched point coincident with the center point of the arc. The sketch, after applying all constraints, is shown in Figure 3-56.

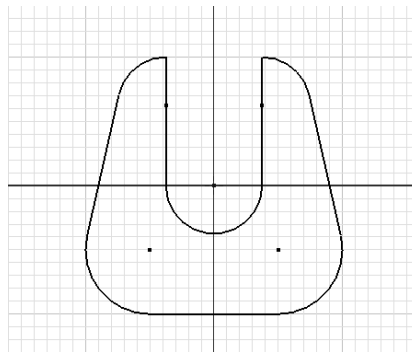


Figure 3-56 The sketch after applying all constraints



Note

The shape of the sketch that you have drawn may be a little different at this stage because of the difference in specifying points while drawing the sketch. However, once all dimensions are applied, the shape of the sketch will be the same. Also, you may need to add vertical constraint to lines 5 and 7 to fully constrain the sketch.

Dimensioning the Sketch

1. Choose the **Dimension** button from the **Constrain** panel of the **Sketch** tab. Next, right-click to display the shortcut menu. From this menu, choose **Edit Dimension** if the check mark is not available on the left of the **Edit Dimension** option. If it



shows the check mark, press the ESC key once to exit the shortcut menu. On doing so, you are prompted to select the geometry to be dimensioned. Select line 1 and place the dimension below the sketch. Modify the value of this dimension in the **Edit Dimension** toolbar to **20**.

2. Select arc 4 and place the dimension on the left of the sketch; the radius dimension for the sketch is placed. Modify the dimension value in the **Edit Dimension** toolbar to **7.5**. The size of arc 8 is also modified because of the **Equal** constraint applied between these two entities.



Note

As discussed in the previous tutorial, you may need to use the combination of hot keys to zoom or pan the model.

3. Select arc 2 and place the radius dimension on the left of the sketch. Modify the dimension value in the **Edit Dimension** toolbar to **10**. The size of the arc 10 is also modified because of the **Equal** constraint applied between these two entities.
4. Select line 5 and then line 7, and then place the dimension above the sketch. Modify the value of this dimension in the **Edit Dimension** toolbar to **15**.
5. Select line 7 and place the dimension on the right of the sketch. Modify the value of this dimension in the **Edit Dimension** toolbar to **20**.
6. Select the upper endpoint of line 7 and select line 1, and then place the dimension on the right of the previous dimension. Modify the value of this dimension to **40** and exit from the **Dimension** tool.

With this, all dimensions are applied (see Figure 3-57), except the horizontal dimension between the center points of arcs 4 and 6 or arcs 8 and 6. The need of these dimensions depends on the constraints and dimensions assumed while drawing the sketch. If you are warned that adding any of these dimensions will over-constrain the sketch, choose **Cancel** from the message box. In this case, this dimension is already assumed.

Drawing Circles

Once all the required dimensions and constraints are applied, you need to draw circles. Figure 3-54 indicates that circles are concentric with arcs 2 and 10.

1. To draw concentric circles, choose **Center Point Circle** from the **Draw** panel of the **Sketch** tab; you are prompted to select the center of the circle. Move the cursor close to the center of arc 2. Specify the center point when the cursor snaps to the center point of arc 2 and turns green. Now, move the cursor away from the center and specify a point to size the circle.
2. Similarly, draw the other circle taking the reference of the center of arc 10.

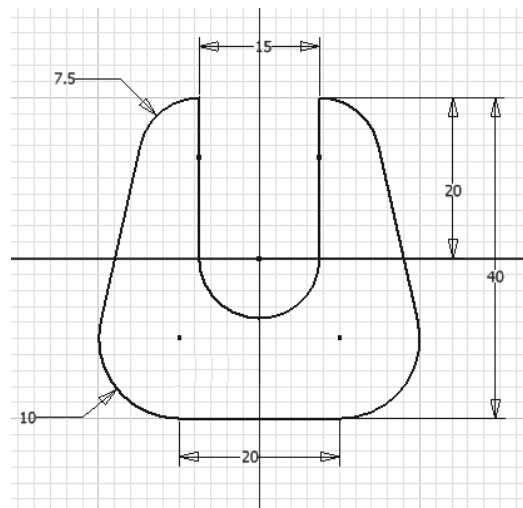


Figure 3-57 Dimensioned sketch for Tutorial 3

Adding Constraints to Circles

As both the circles have the same diameter, you can apply the **Equal** constraint to them. As a result, you have to apply a dimension to just one of them. The other circle will automatically be forced to the specified diameter value because of the **Equal** constraint.

1. Invoke the **Equal** constraint from the **Constrain** panel of the **Sketch** tab. Select the first circle and then the second circle to apply the **Equal** constraint.



Dimensioning the Circle

1. Choose **Dimension** from the **Constrain** panel of the **Sketch** tab and select the left circle. Place the dimension on the left of the sketch. In the **Edit Dimension** toolbar, change the value of the diameter of the circle to 8.



Notice that the size of the right circle is automatically modified to match the dimension of the left circle. This is because the **Equal** constraint is applied between the two circles. The final sketch for Tutorial 3, after drawing and dimensioning circles, is shown in Figure 3-58.

Saving the Sketch

1. Choose the **Return** button from the **Quick Access Toolbar** to exit the sketching environment. Save this sketch with the name *Tutorial3* and at the location given below:

C:\Inventor_2010\c03.

2. Choose **Close > Close** from the **Application Menu** to close the file.

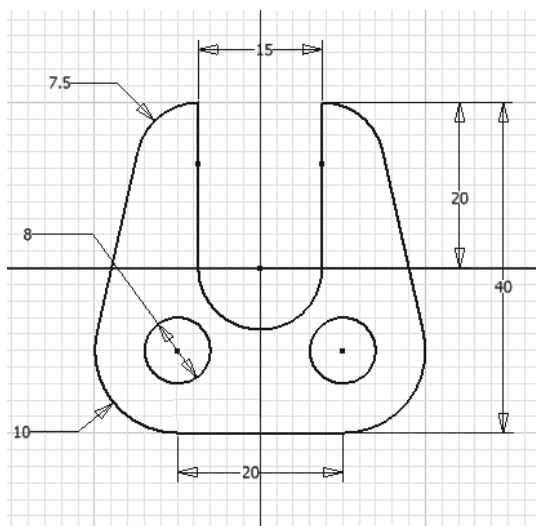


Figure 3-58 The final dimensioned sketch for Tutorial 3

Tutorial 4

In this tutorial, you will draw the sketch for the model shown in Figure 3-59. The dimensions of the sketch are shown in Figure 3-60. After drawing, add constraints and then dimension it. The solid model is given for reference only. **(Expected time: 30 min)**

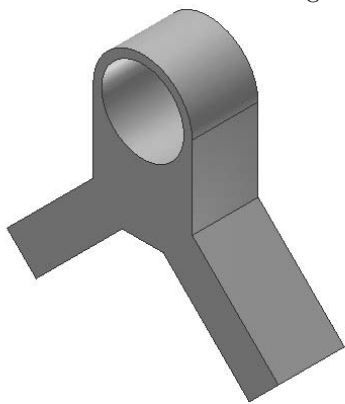


Figure 3-59 Model for the sketch of Tutorial 4

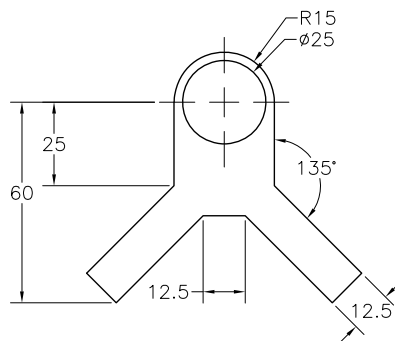


Figure 3-60 Dimensions of the sketch

The following steps are required to complete this tutorial:

- Start a new metric standard part file and draw the outer loop of the sketch.
- Add the required dimensions and constraints to the sketch.
- Add the inner circle and dimension it.
- Save the sketch with the name *Tutorial4.ipt* and close the file.

Starting a New File

1. Choose the **New** button from the **Quick Access Toolbar** to display the **New File** dialog box. Start a new metric standard part file from the **Metric** tab of this dialog box.

Drawing the Outer Loop

1. Choose **Line** from the **Draw** panel of the **Sketch** tab to draw the outer loop, as shown in Figure 3-61. As mentioned earlier, you should draw the inner loop after drawing and dimensioning the outer loop. This is because once the outer loop is dimensioned, you can draw the inner loop by taking the reference of the outer loop.

You can use the option for drawing the arc within the **Line** tool to draw it in the sketch. You can also use the temporary tracking option for drawing this sketch. For your reference, the geometries in the sketch are numbered, see Figure 3-61.

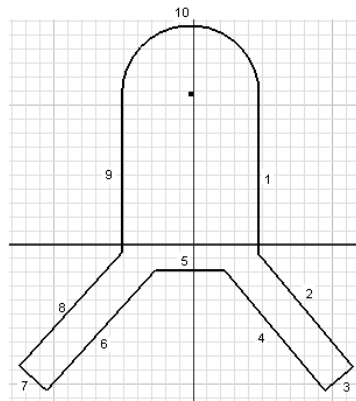



Figure 3-61 Initial sketch with the geometries numbered

Adding Constraints to the Outer Loop

1. Add the **Equal** constraint to lines 1 and 9, lines 2 and 8, lines 3 and 5, lines 5 and 7, and lines 4 and 6.
2. Add the **Perpendicular** constraint to lines 2 and 3, and lines 7 and 8.
3. Add the **Horizontal** constraint to line 5 and between the lower endpoints of lines 4 and 6.
4. Add the **Tangent** constraint to lines 1 and 9 with arc 10.
5. Add the **Parallel Constraint** between lines 1 and 9, lines 2 and 4, and lines 6 and 8.
6. Add the **Vertical Constraint** to line 1.






Dimensioning the Outer Loop

1. Choose the **Dimension** button from the **Constrain** panel of the **Sketch** tab; you are prompted to select the geometry to dimension. Select line 9 and place the dimension on the left of the sketch. Modify the dimension value in the **Edit Dimension** toolbar to **25**. 
2. Select the center of the arc and then select the lower endpoint of line 6. Place the dimension on the left of the previous dimension. Modify the dimension value in the **Edit Dimension** toolbar to **60**.
3. Select line 3 and then right-click to display the shortcut menu. Choose **Aligned** from the shortcut menu and then place the dimension below the sketch. Modify the value in the **Edit Dimension** toolbar to **12.5**.

Notice that the length of lines 5 and 7 is also modified due to the **Equal** constraint.

4. Select lines 1 and 2, and then place the angular dimension on the right of the sketch. Modify the value of the angular dimension in the **Edit Dimension** toolbar to **135**.
5. Select arc 10 and then place the radius dimension above the sketch. Modify the value of the radius of the arc in the **Edit Dimension** toolbar to **15**.

With this, the required dimensions are applied to the outer loop. Even after adding all dimensions, the color of entities in the sketch is still black. To fully constrain the sketch, you need to place a sketch point at the origin and then constrain it.

6. Choose the **Point** button from the **Draw** panel of the **Sketch** tab and place the point at the origin. You can also use the **Precise Input** toolbar to place the point. 
7. Next, choose the **Fix** button from the **Constrain** panel of the **Sketch** tab; you are prompted to select a curve or a point to be fixed. 
8. Select the sketch point that you placed at the origin. The point is fixed at the origin and you can now use it to fully constrain the initial sketch.
9. Choose the **Coincident Constraint** button from the **Constrain** panel of the **Sketch** tab; you are prompted to select the first curve or point. 
10. Select the center of the arc; you are prompted to select the second curve or point.
11. Select the sketch point that you placed at the origin. The entire sketch shifts itself such that the center of arc of the sketch is now at the origin. But, the sketch is not completely visible in the drawing window.

12. Choose the **Zoom All** button from the **Navigation Bar** to fit the sketch into the drawing window. You will notice that all entities in the sketch turn blue, indicating that the sketch is fully constrained. Press the ESC key to exit the **Coincident Constraint** tool.

Drawing the Circle

1. Choose **Center Point Circle** from the **Draw** panel of the **Sketch** tab; you are prompted to select the center of the circle.
2. Move the cursor close to the center of the arc; the cursor snaps to the center point and turns green. Select this point as the center of the circle and then move the cursor away from the center to size the circle. Specify a point to give it an approximate size.

Dimensioning the Circle

1. Choose **Dimension** from the **Constrain** panel of the **Sketch** tab and select the circle. Place the diameter dimension below the arc dimension. Enter the diameter of the circle in the **Edit Dimension** toolbar as **25**.



This completes the sketch for Tutorial 4. The final dimensioned sketch is shown in Figure 3-62.

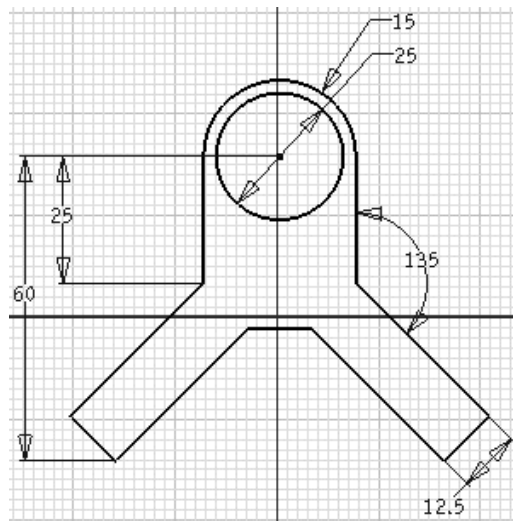


Figure 3-62 The final dimensioned sketch for Tutorial 4

Saving the Sketch

1. Choose the **Finish Sketch** button from the **Exit** panel of the **Sketch** tab to exit the sketching environment and then save the sketch with the name *Tutorial4* at the location given below:

C:\Inventor_2010\c03

2. Choose **Close > Close** from the **Application Menu** to close the file.

Self-Evaluation Test

Answer the following questions and then compare them to those given at the end of this chapter:

1. The **Perpendicular Constraint** forces the selected entity to become perpendicular to the specified entity. (T/F)
2. The **Coincident Constraint** can be applied to two line segments. (T/F)
3. The **Collinear Constraint** can only be applied to line segments. (T/F)
4. If you apply an unnecessary constraint in the sketch, Autodesk Inventor displays a message box informing you that adding this constraint will over-constrain the sketch. (T/F)
5. The _____ nature of Autodesk Inventor ensures that irrespective of the original size, the selected entity is driven to the specified dimension value.
6. When you select a circle to be dimensioned, the _____ dimension is applied to it by default.
7. The _____ dimension has one arrowhead and is placed outside the circle or arc.
8. The _____ dimension displays the distance between the two selected line segments in terms of diameter, which is double the original length.
9. The _____ tool is used to measure the radius of an arc.
10. A _____ constrained sketch is the one whose all entities are completely constrained to their surroundings using constraints and dimensions.

Review Questions

Answer the following questions:

1. You cannot apply the **Concentric** constraint between a point and a circle. (T/F)
2. You can use the **Horizontal** or **Vertical** constraint to line up arcs, circles, or ellipses in the same horizontal or vertical direction. (T/F)
3. You can view all, or some of the constraints applied to a sketch. (T/F)
4. There are twelve types of geometric constraints that can be applied additionally to the sketched entities. (T/F)

5. The linear dimensions are the dimensions that define the shortest distance between two points. (T/F)
6. The situation, where the number of dimensions or constraints exceeds the number that is required in a sketch, is called
 - (a) Constraint
 - (b) Under-constrained
 - (c) Over-constrained
 - (d) None of the above
7. Which of the following toolbars does the **Measure Distance** toolbar change to when you invoke the **Distance** tool and select two lines?
 - (a) **Length**
 - (b) **Distance**
 - (c) **Minimum Distance**
 - (d) None of the above
8. Which of the following dimensions is applied to the arc by default whenever you select an arc to be dimensioned?
 - (a) **Radius**
 - (b) **Diameter**
 - (c) **Linear**
 - (d) **Linear Diameter**
9. In addition to lines, which of the following entities can be selected to apply the **Collinear** constraint?
 - (a) Arc
 - (b) Circle
 - (c) Ellipse
 - (d) Ellipse axis
10. Which of the following combination of entities cannot be used to apply the **Tangent** constraint?
 - (a) Line, line
 - (b) Line, arc
 - (c) Circle, circle
 - (d) Arc, circle

Exercises

Exercise 1

Draw the basic sketch for the model shown in Figure 3-63. The sketch is shown in Figure 3-64. After drawing the sketch, add the required constraints and then dimension it.

(Expected time: 30 min)

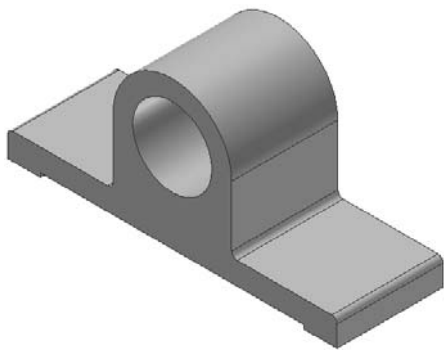


Figure 3-63 Model for Exercise 1

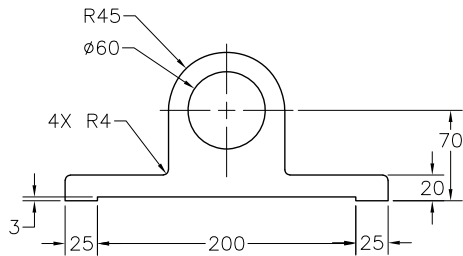


Figure 3-64 Sketch for Exercise 1

Exercise 2

Draw the basic sketch for the model shown in Figure 3-65. The sketch is shown in Figure 3-66. After drawing the sketch, add the required constraints to it and then dimension it.

(Expected time: 30 min)

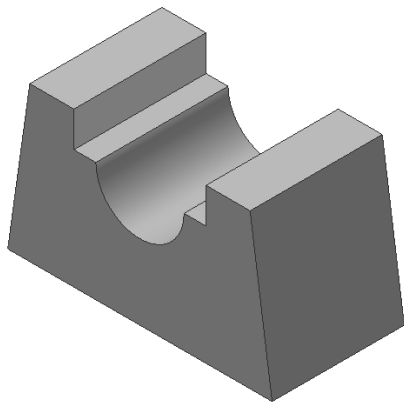


Figure 3-65 Model for Exercise 2

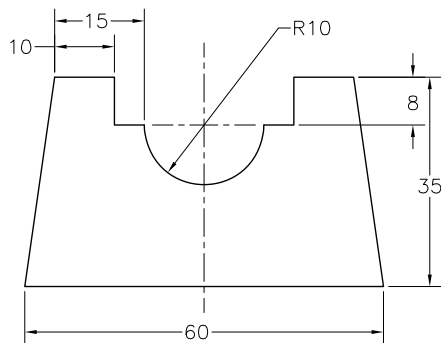


Figure 3-66 Sketch for Exercise 2

Exercise 3

Redraw the sketch of Exercise 1 of Chapter 2 without using the **Inventor Precise Input** toolbar. After drawing the sketch, add the required constraints to it and then dimension it. The dimensioned sketch is shown in Figure 3-67.

(Expected time: 30 min)

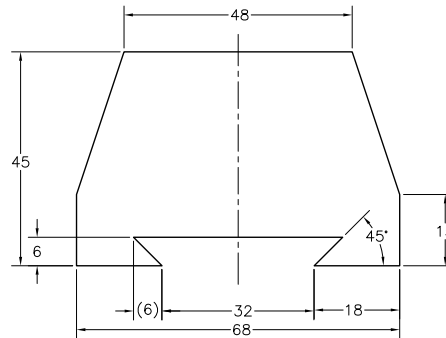


Figure 3-67 Dimensioned sketch for Exercise 3

Exercise 4

Redraw the sketch of Exercise 2 of Chapter 2 without using the **Inventor Precise Input** toolbar. After drawing the sketch, add the required constraints to it and then dimension it. The dimensioned sketch is shown in Figure 3-68. **(Expected time: 30 min)**

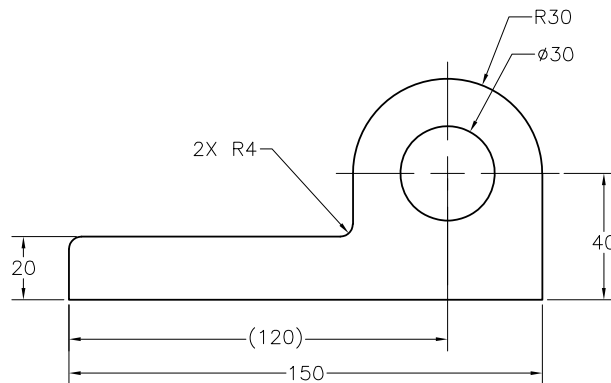


Figure 3-68 Dimensioned sketch for Exercise 4

Exercise 5

Draw the basic sketch for the model shown in Figure 3-69. The sketch to be drawn is shown in Figure 3-70. After drawing the sketch, add the required constraints and then dimension it.

(Expected time: 30 min)

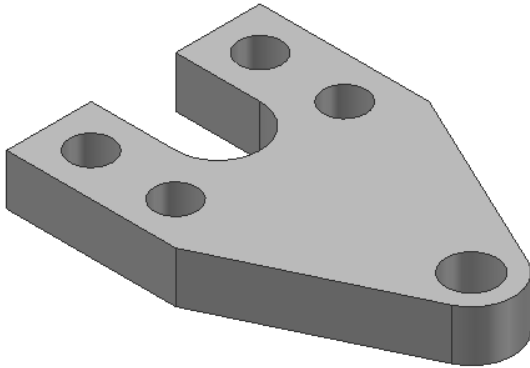


Figure 3-69 Model for Exercise 5

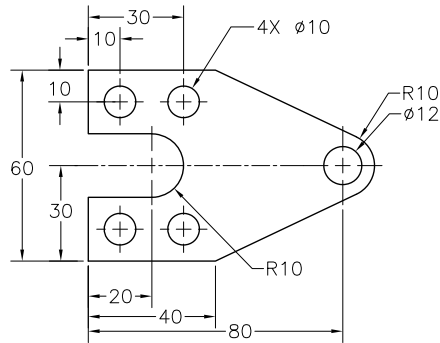


Figure 3-70 Sketch for Exercise 5

Answers to Self-Evaluation Test

1. T, 2. F, 3. F, 4. T, 5. parametric, 6. diameter, 7. radius, 8. linear diameter, 9. Measure Distance, 10. fully