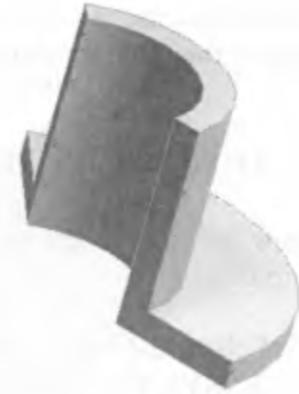


# Chapter 1

## *Solid Modeling Fundamentals*



### 1-1 OVERVIEW

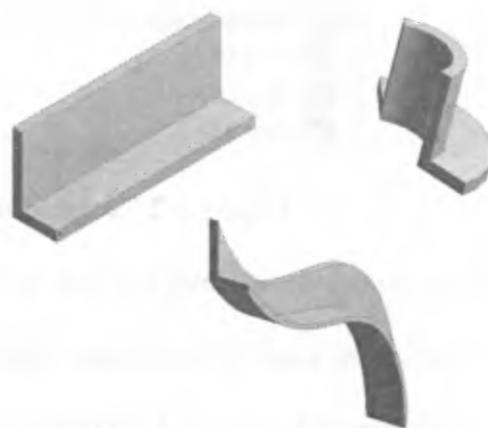
A simple **L-shaped cross section** is used to introduce basic solid modeling concepts with ANSYS DesignModeler. These tutorials explore solid modeling by:

- ◆ Extruding
- ◆ Revolving
- ◆ Sweeping

A number of additional parametric, feature-based modeling possibilities and formulations are demonstrated in this chapter.

### 1-2 INTRODUCTION

Solid modeling can be accomplished in a number of ways, and one favorite method involves starting with a two-dimensional shape and manipulating it to create a solid. That is the approach we will use for many of the object models created in this book. Figure 1-1 shows an L-shaped cross section that has been variously **extruded**, **revolved**, or **swept along a curve** to produce the solid object models shown.



**Figure 1-1** Extruding, revolving, sweeping an L-shaped section.

In the following we use this simple L-shaped section as well as a circular section to illustrate the three fundamental solid modeling approaches mentioned above.

### 1-3 TUTORIAL 1A – EXTRUSION

Follow the steps below to create a **solid model** of an **extrusion** with an **L-shaped** cross section.

1. Follow the steps outlined in the previous chapter Figures I-1 through I-4 to Start **ANSYS Workbench**. Double click **Geometry** or drag **Geometry** into the **Project Schematic** as shown below.

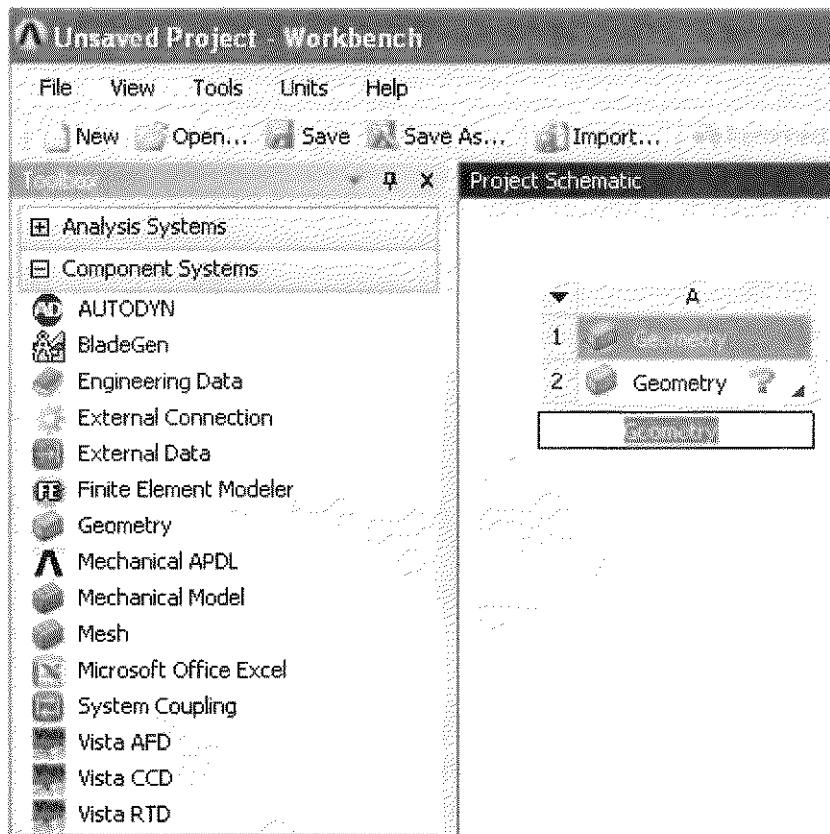


Figure 1-2 DesignModeler in the Project Schematic.

The question mark indicates that **cell A-2** is incomplete.

2. Select the **small blue triangle** for additional information.
3. **Double click cell A-2 Geometry** to start **DesignModeler**. Select **millimeter** length units > **OK**.

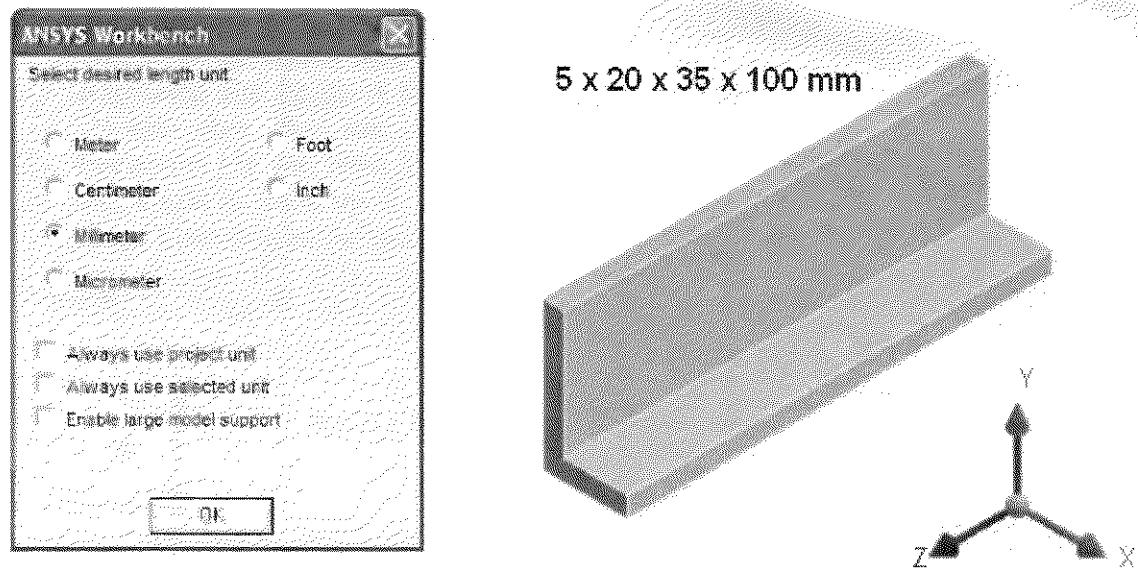


Figure 1-3 T1A solid.

We will sketch the L-shaped cross section on the XY Plane. Make it 35 mm high, 20 mm wide with 5 mm thick legs.

4. Select XYPlane as in the figure below. Then click on the Look at icon to view the XYPlane.

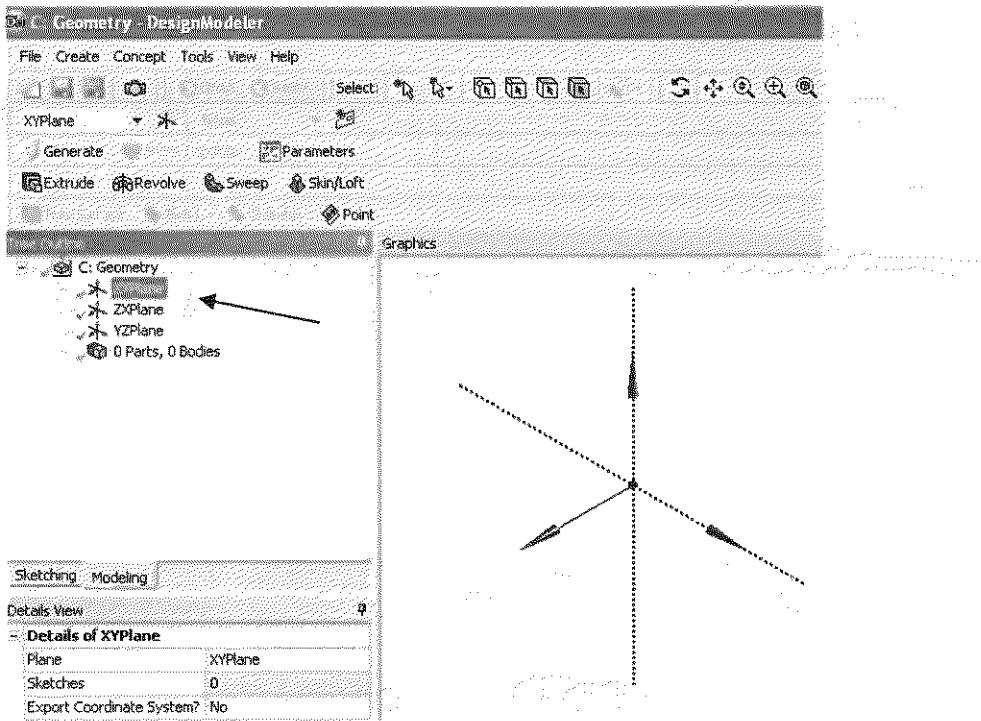
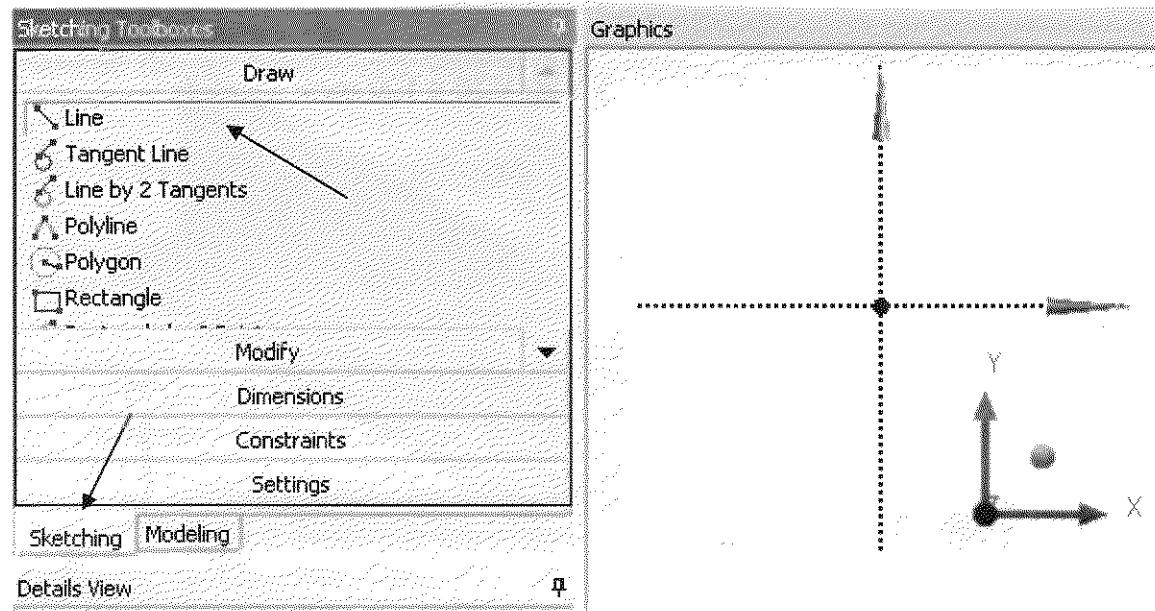


Figure 1-4 Select the sketching plane.

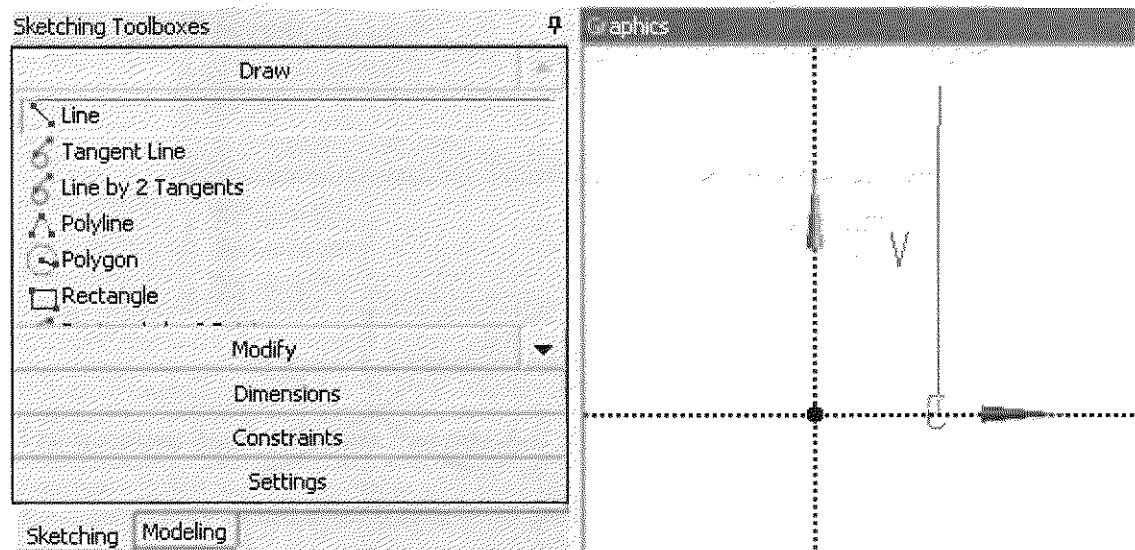


**Figure 1-5** Sketching on the plane XY plane.

5. **Sketching.** Change from Modeling to Sketching by selecting the Sketching tab.

Select **Draw > Line**

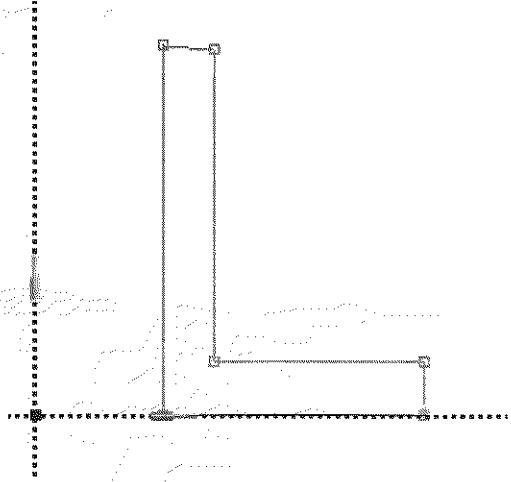
6. Use the line drawing tool to draw the left vertical edge of the L-shape. Left click at the beginning and again at the end of the line. The V indicates that you've got it exactly vertical.



**Figure 1-6** Left edge of the L-shape.

7. Continue sketching until you have something like what is shown below. Left click at the beginning and again at the end of each line. (Notice that the top edge is not quite horizontal.) If you need to change something, use **Undo** to back up or use **New Selection**, **Edge** filter to select a line, press the delete key and redraw it. Also note that the cursor changes shape when it is snapped onto another point or axis.

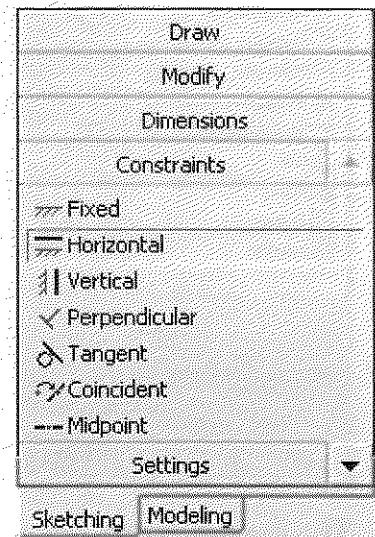
Figure 1-7 L-section sketch.



Use the **constraints** options **horizontal** to make the top edge horizontal and **equal length** to make sure that the vertical and horizontal legs of the L are of the same thickness.

8. Sketching > Constraints > Horizontal – Left click the top edge.

Figure 1-8 Sketching constraints.



9. Sketching > Constraints > Equal length – Left Click the top edge and then the right edge.

The figure is just a sketch so far, and a number of different dimensioning schemes could be used to produce the section we want. We will use the **Sketching > Dimensions** options to give it the desired properties.

10. Sketching > Dimensions > General – Left click and (hold down the button) on the left vertical edge of the section and drag the dimension to place.

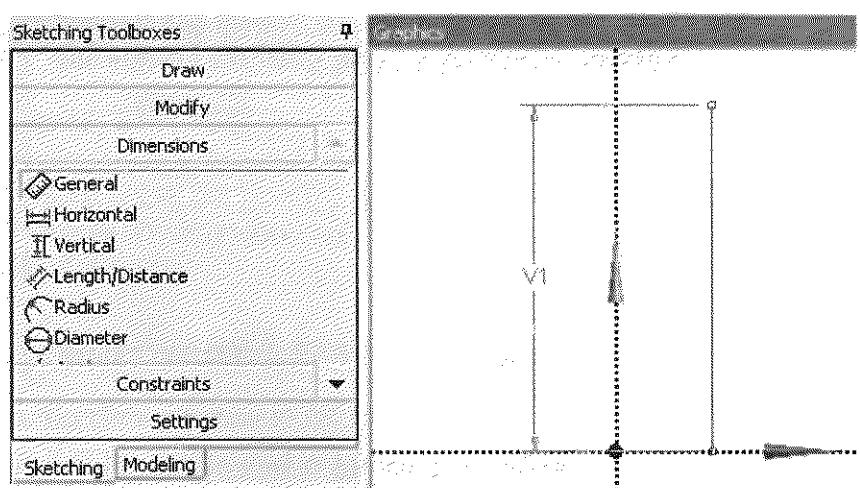


Figure 1-9 Left edge.

The V1 means this is the first vertical dimension for this sketch. Continue with General dimensioning to specify H3 and V2. Don't dimension the top edge; it has to be equal to V2. The bottom edge is located directly on the X axis but we need to locate the vertical edge with respect to the Y axis.

11. Sketching > Dimensions > Horizontal – Left click the left vertical edge then click the dotted Y axis and drag the H3 dimension to a convenient location.

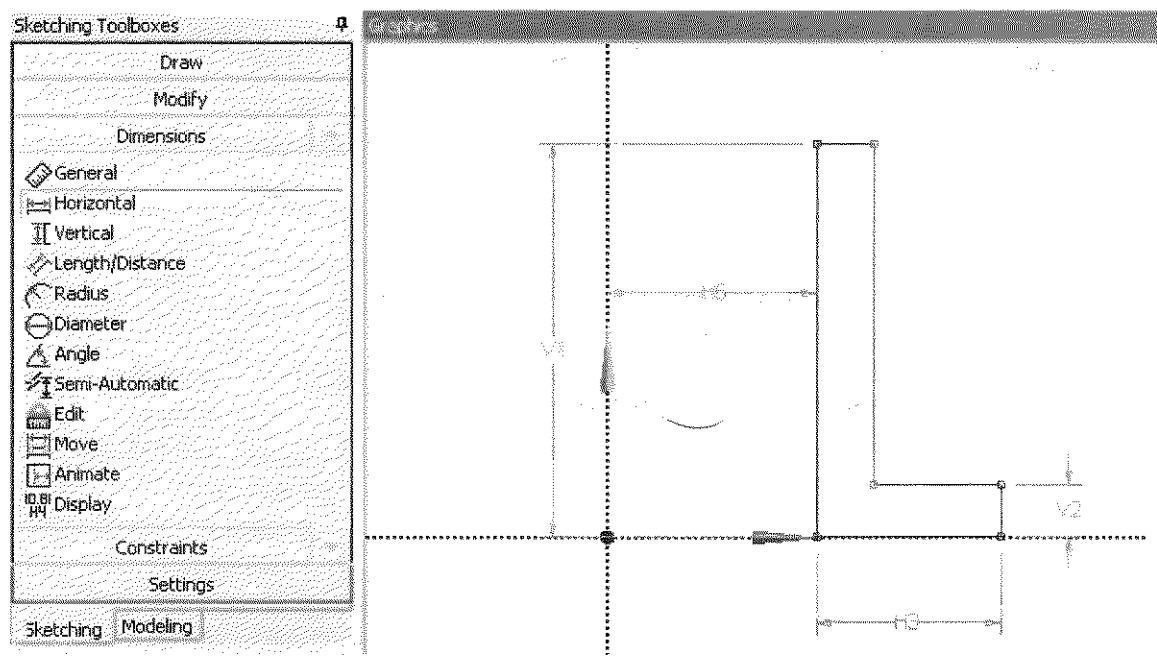


Figure 1-10 L-section sketch with all dimensions.

The current values for the dimensions depend upon the scale used in the sketching process, e.g., H3 = 21.126 mm in the **Details of Sketch1** box shown in figure above.

12. Edit the dimensions to give them the desired values. – Click on a value, enter the change and press return.

Details View	
- Details of Sketch1	
Sketch	Sketch1
Sketch Visibility	Show Sketch
Show Constraints?	No
<b>Dimensions: 4</b>	
H3	26.167 mm
H5	14.807 mm
V1	39.709 mm
V2	5.2282 mm

Figure 1-11 Default dimension values.

13. View > Ruler (Top menu) to turn off the ruler display. Use the middle mouse roller to zoom in and out.

To reposition the section on the screen, **Right Click** in the graphics area of the display and select one of the following options: **Cursor Mode**, **View**, or **Zoom to Fit**.

The result is shown in the figure below.

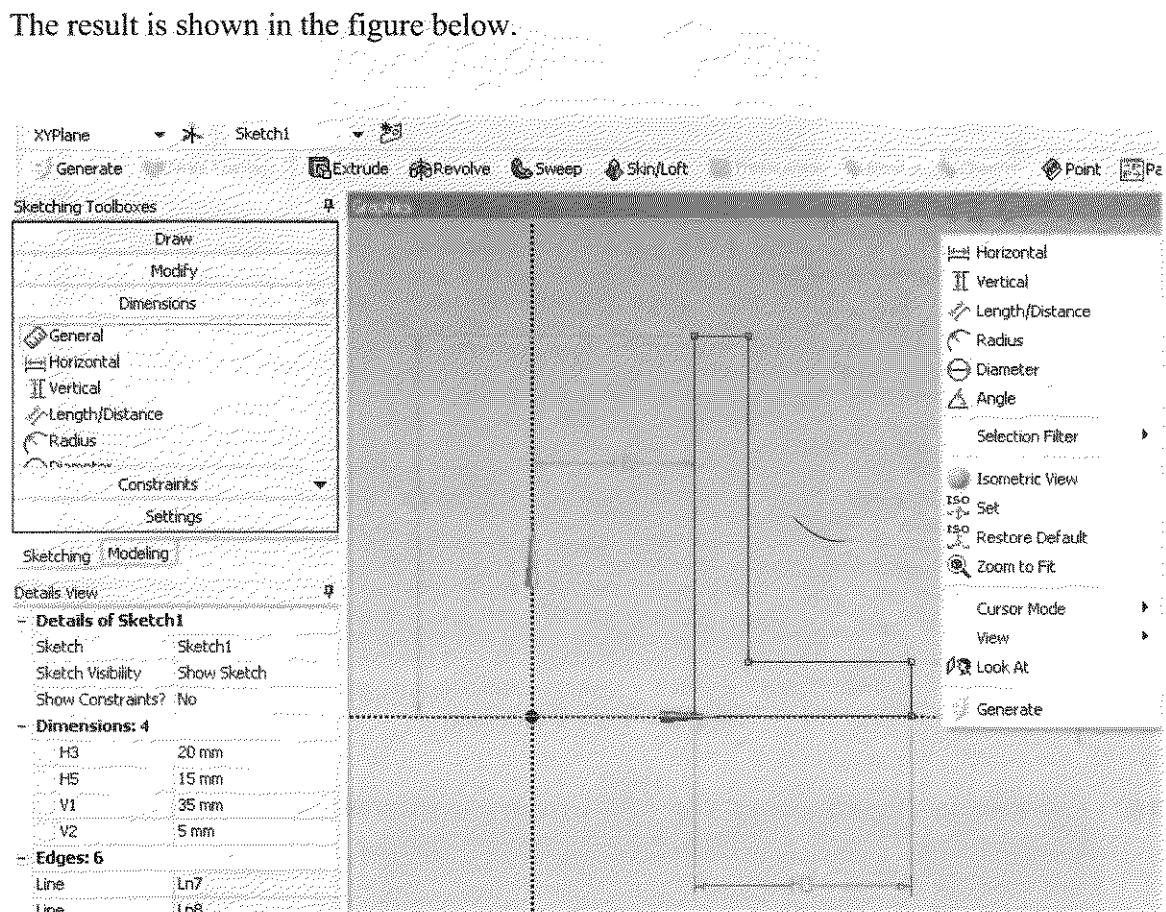


Figure 1-12 Edited dimension values.

To perform the extrusion, switch back from Sketching to Modeling. If it is not already highlighted, click **Sketch1** in the **Tree Outline** to highlight it.

#### 14. Modeling > Sketch1 > Extrude



The L-shaped section will be extruded along the positive Z axis by the amount specified in the **Depth** field shown in the **Details of Extrude1** box (Figure 1-14). Edit this value to give the solid an extrude **depth** of **100 mm**.

The tree structure shows the components from which the solid model is created.

#### 15. Click the **Generate** icon to complete creation of the extruded shape model.



In the graphics area of the display **Right click > View > Isometric** (or hold down the middle mouse button and rotate the object).

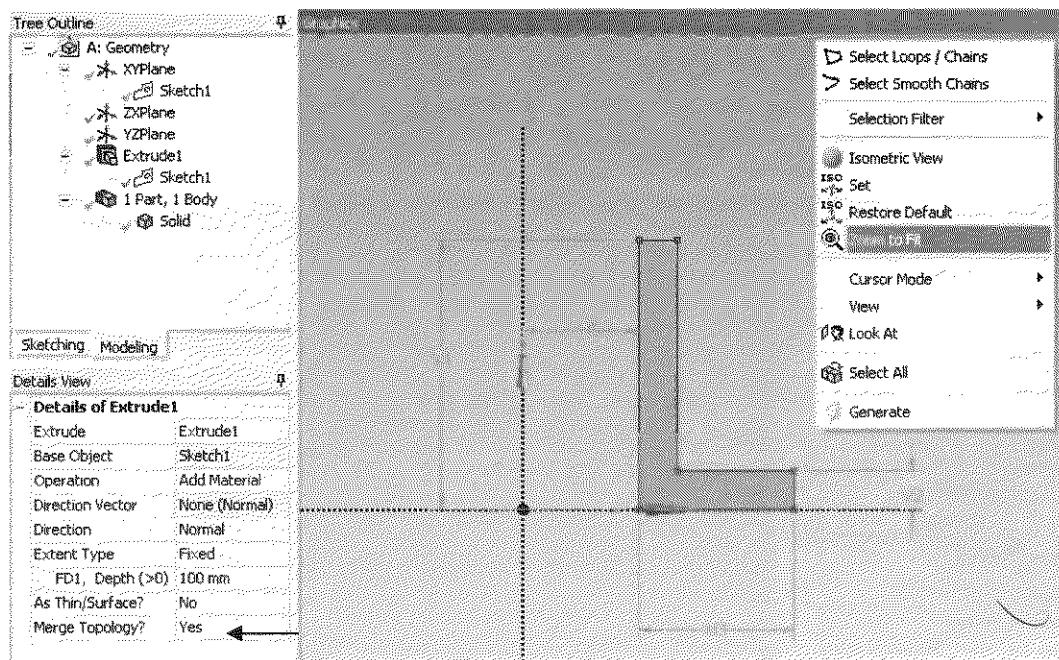


Figure 1-13 Extrusion.

16. Click on the **Display Plane** icon  to turn off the axes display and high-light the last item in the model tree (Solid) to display the volume, surface area, faces, edges and vertices in this model.

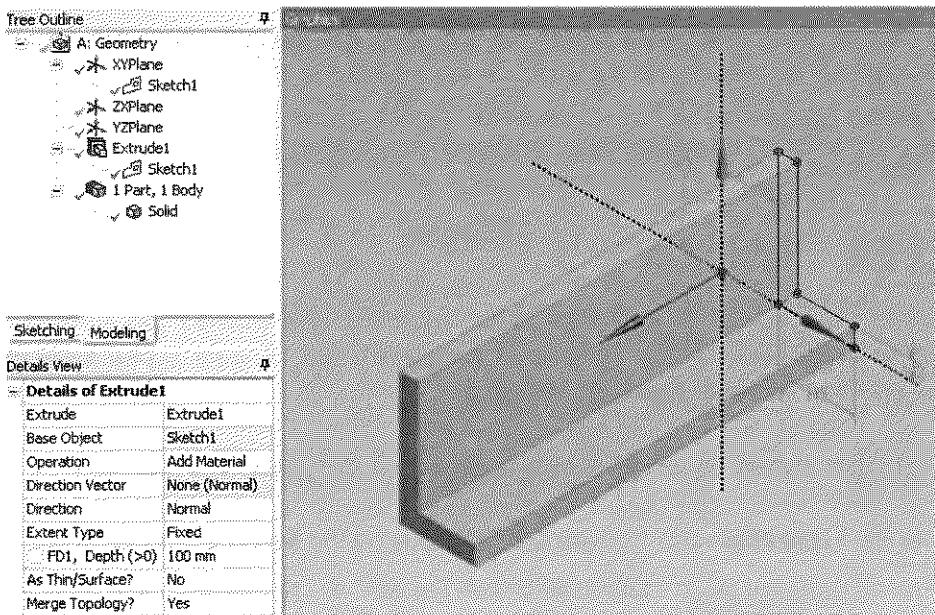


Figure 1-14 Extruded solid.

17. **Save your work** – Use the **Save As** option to save the extrusion using a name (e.g. T1A) and location of your choice.

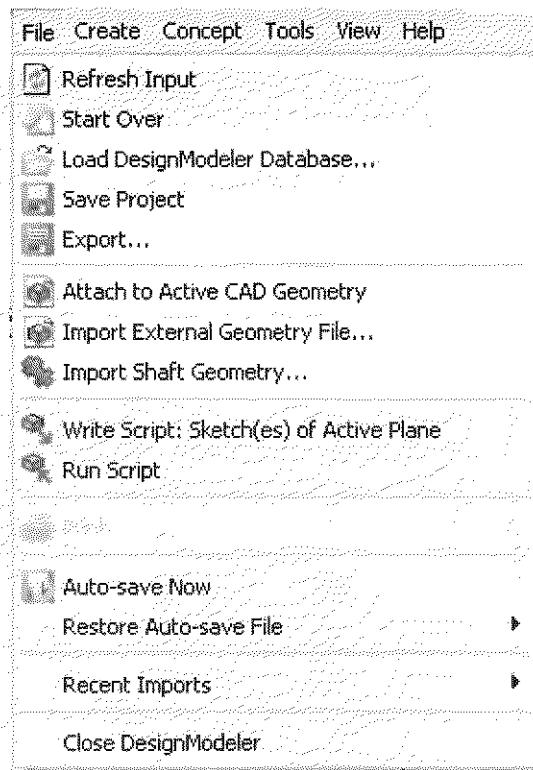


Figure 1-15 File menu.

Basic solid modeling notions have been used thus far to demonstrate creating a solid by extruding a two-dimensional section. In the next tutorial we will revolve the same L-shape to create a solid of revolution.

#### 1-4 TUTORIAL 1B – REVOLUTION

We can reuse the extrusion model from the previous tutorial after it has been safely saved. Start from the screen shown below if the extrusion is still in memory, or start Workbench and reload the extrusion. First modify the tree structure.

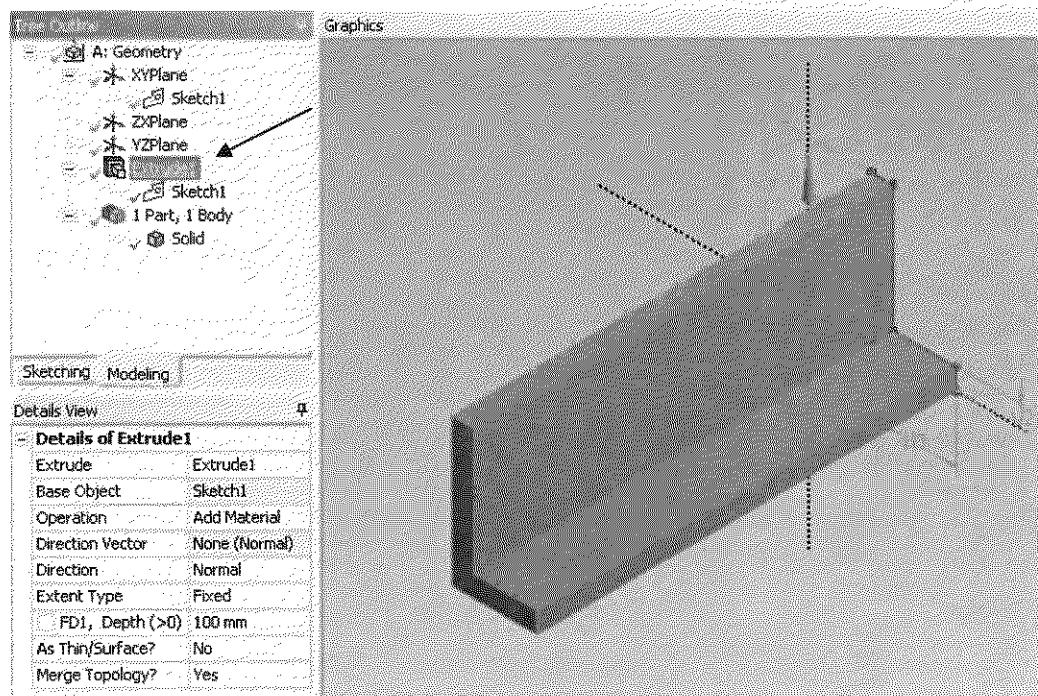


Figure 1-16 Select the extrusion.

1. Click on **Extrude1** and press **Delete**. Click **Yes** to the query. The extrusion is deleted and the new tree structure shows 0 Parts and 0 Bodies.

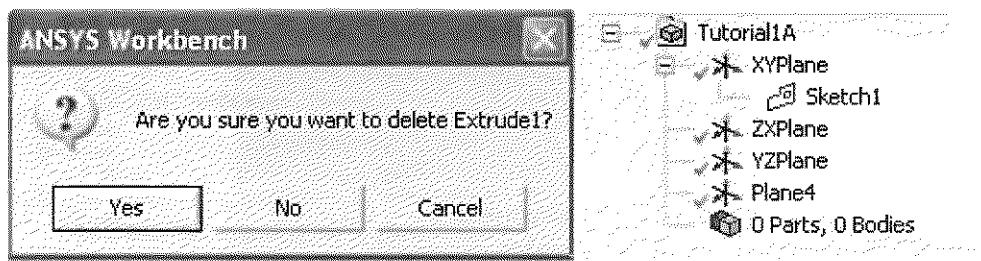
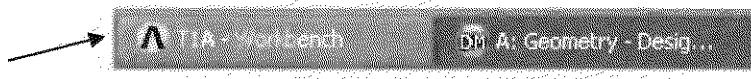


Figure 1-17 Delete the extrusion.

2. Return to the Project Schematic and use **Save As** to save this work using a new file name, say **Tutorial1B**.



3. Click on **Sketch1**, the **Display Plane** icon  and the **Look at Plane** icon 

We obtain the view of the same sketch we had earlier.

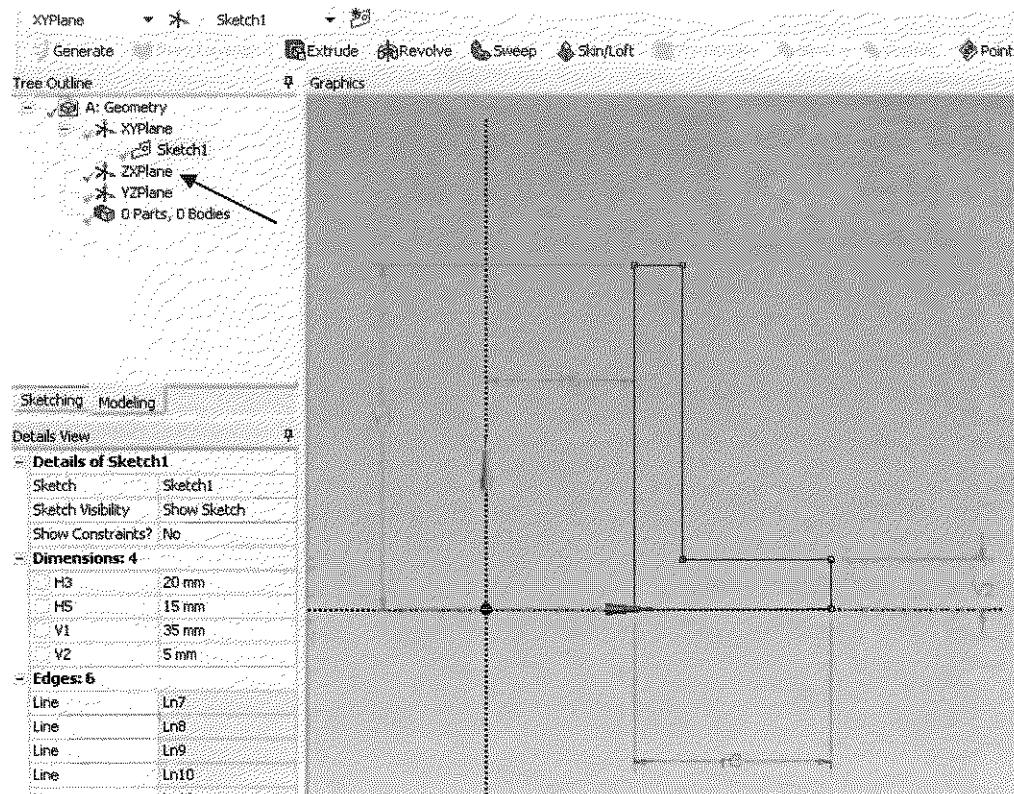
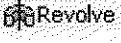


Figure 1-18 Select the sketch.

4. Be sure Sketch1 is highlighted and Click Revolve. 
5. Click Axis > Select the Y axis > Apply in Details of Revolve1 box.
6. Select Angle > Enter 120 deg. 
7. Click Generate. 

The L-shaped section is rotated about the Y axis by 120 degrees to create the solid of revolution shown next. Direction options change the rotation direction.

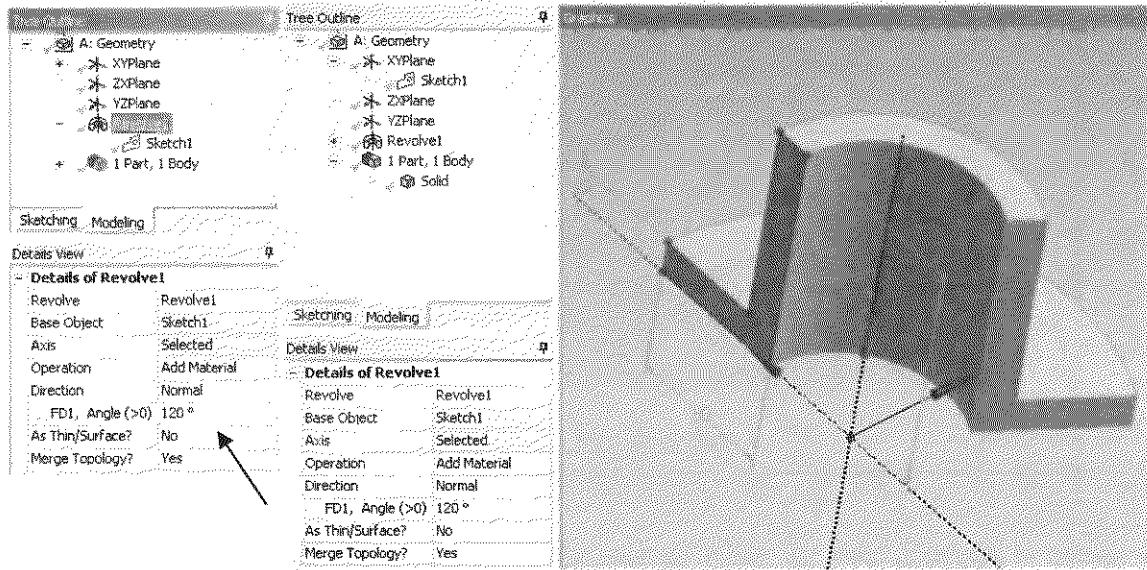


Figure 1-19 Solid of revolution.

8. Save to archive your work.

Next we will take a **circular cross section** and **sweep it along a circular path** to illustrate the third kind of modeling discussed in this chapter.

## 1-5 TUTORIAL 1C – SWEEP

1. Start DesignModeler. Sketch a 2 mm diameter circle on the XYPlane as before. We get the sketch1 figure shown. Save this file as T1C or something convenient.

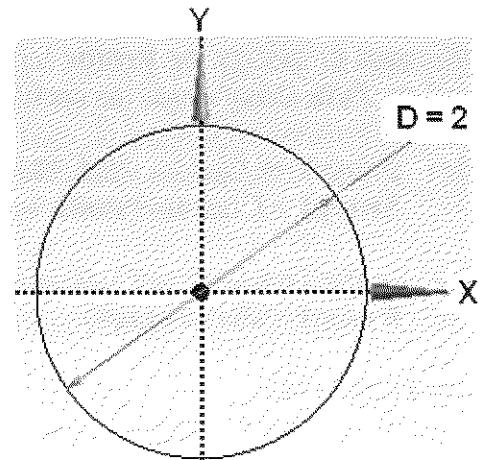


Figure 1-20 Cross section, sketch1.

We now want to sketch a path along which the circular shape will be swept to produce a solid. We will use a simple curve to define this path.

2. Select the YZPlane and Select Sketching.
3. Use the Circle and Trim options to sketch a semi-circle of Radius 20 mm in the YZPlane as shown below. Note that at the origin of the path, sketch2, is perpendicular to the cross section, sketch1.

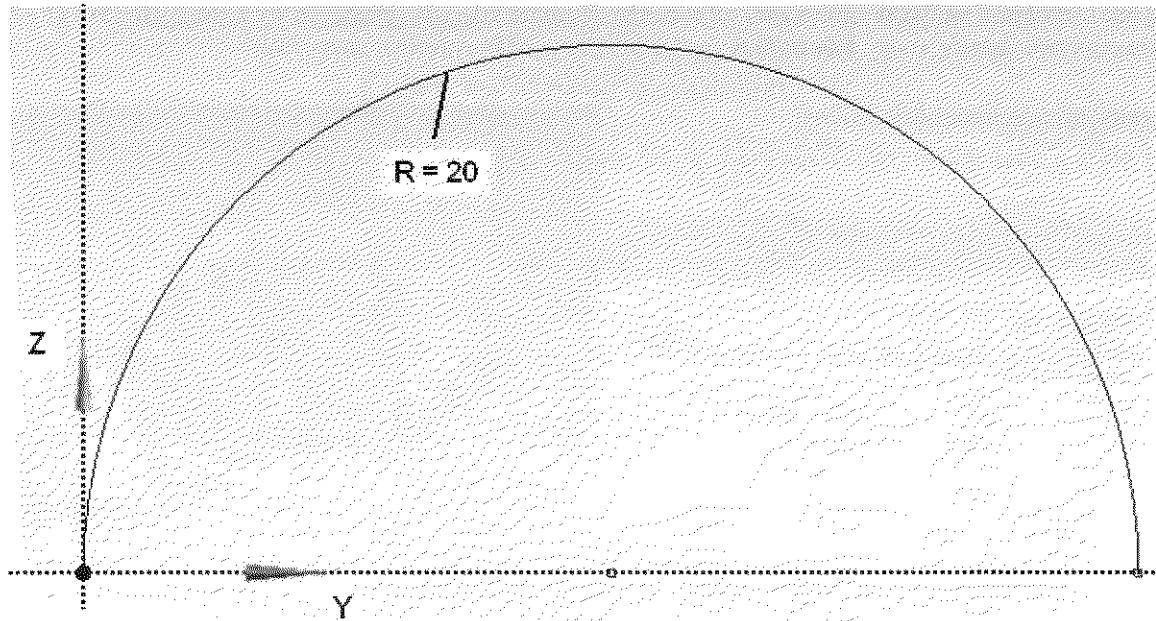


Figure 1-21 Path of sweep, sketch2.

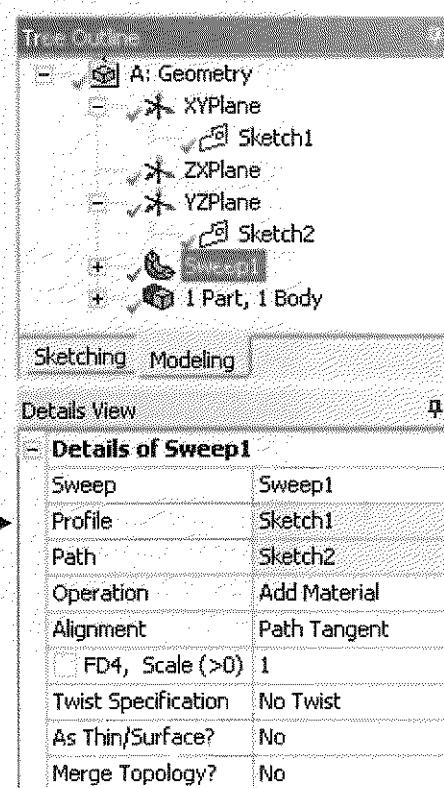
4. Select Sweep to create the solid. 

We need to specify the **Profile** (cross section) of the solid and the **Path** along which the profile will be swept.

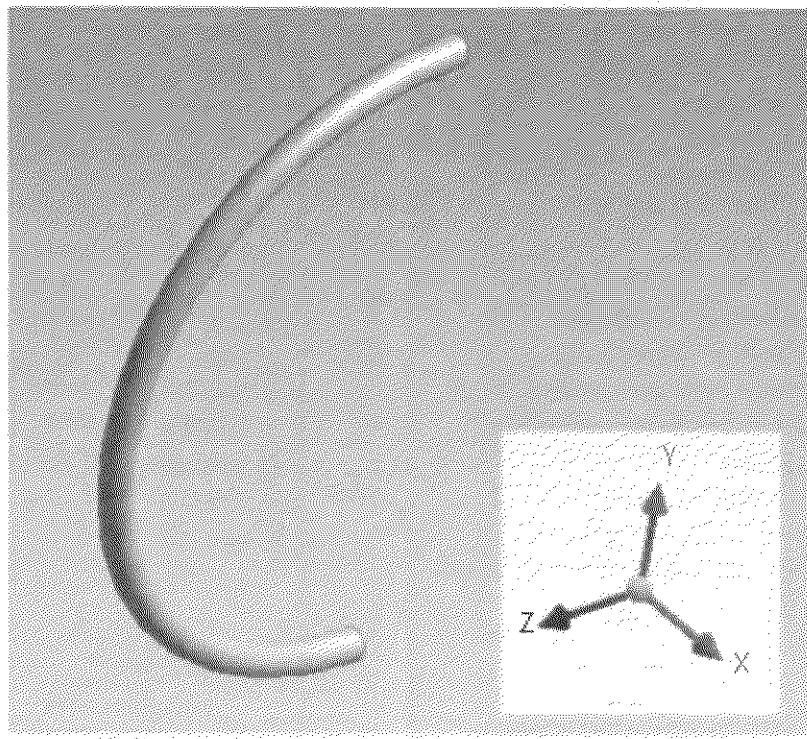
5. In the Tree Outline Click Sketch1, then in **Details of Sweep1** > Click on **Profile** > **Apply**.
6. In the Tree Outline Click Sketch2, then in **Details of Sweep1** > **Path** > **Apply**.

See Figure 1-22.

Figure 1-22 Profile and path selection.



7. Generate to obtain the solid shown next.



**Figure 1-23** Swept solid.

Notice that the profile is perpendicular to the path as when we used Extrude to create a solid. Also the path can be a more complex curve as in the example of Figure 1-1 where a spline was used for the path.

## 1-6 SKETCHING

A wide variety of sketching tools are available to help in creating two-dimensional sections. We used the line drawing option and the equality constraint option in the tutorials above. Some of the other sketching features are shown below.

The next illustration shows the **Draw** and **Modify** options. The **Draw** menu includes **Line**, **Tangent Line**, **Line by two Tangents**, **Polyline**, **Polygon**, **Rectangle**, **Oval**, **Circle**, **Arc**, **Ellipse**, **Spline** and **Construction Point**.

The **Modify** menu includes **Fillet**, **Chamfer**, **Trim**, **Extend**, **Split**, **Drag**, **Cut**, **Copy**, **Paste**, **Move**, **Replicate** and **Offset**.

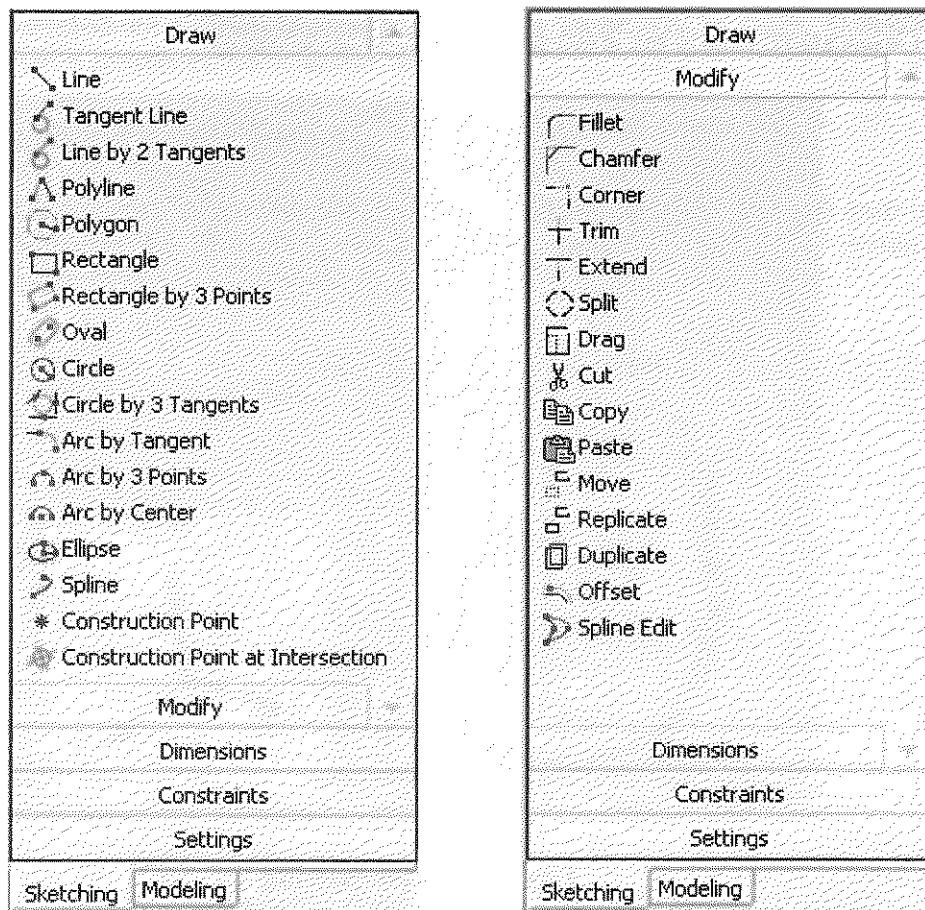


Figure 1-24 Draw and Modify sketching options.

We will have the occasion to illustrate the use of many of these options in what follows. Menu selections for assigning **Dimensions** and enforcing **Constraints** are shown in the next figure.

In addition to a **General** dimension specification, dimensions can be assigned which are **Horizontal**, **Vertical**, **Length/Distance**, **Radius/Diameter**, or an **Angle**. Select **Semi-Automatic Dimensioning** if you want DesignModeler to select a dimensioning scheme automatically. You then have the option to accept, add or delete dimensions to meet your specific design needs.

**Constraints** that can be enforced for sketching entities include **Horizontal**, **Vertical**, **Perpendicular**, **Tangent**, **Coincident**, **Midpoint**, **Symmetric**, **Parallel**, **Concentric**, **Equal Radius**, **Equal Length** and **Equal Distance**.

As sketching proceeds DesignModeler will attempt to detect and enforce constraints that seem to be part of the design intent of the sketch. The **Auto Constraints** option allows you to turn these on and off as desired. **Cursor** triggered constraints are local, while **Global** constraints relate to all entities in the sketching plane.

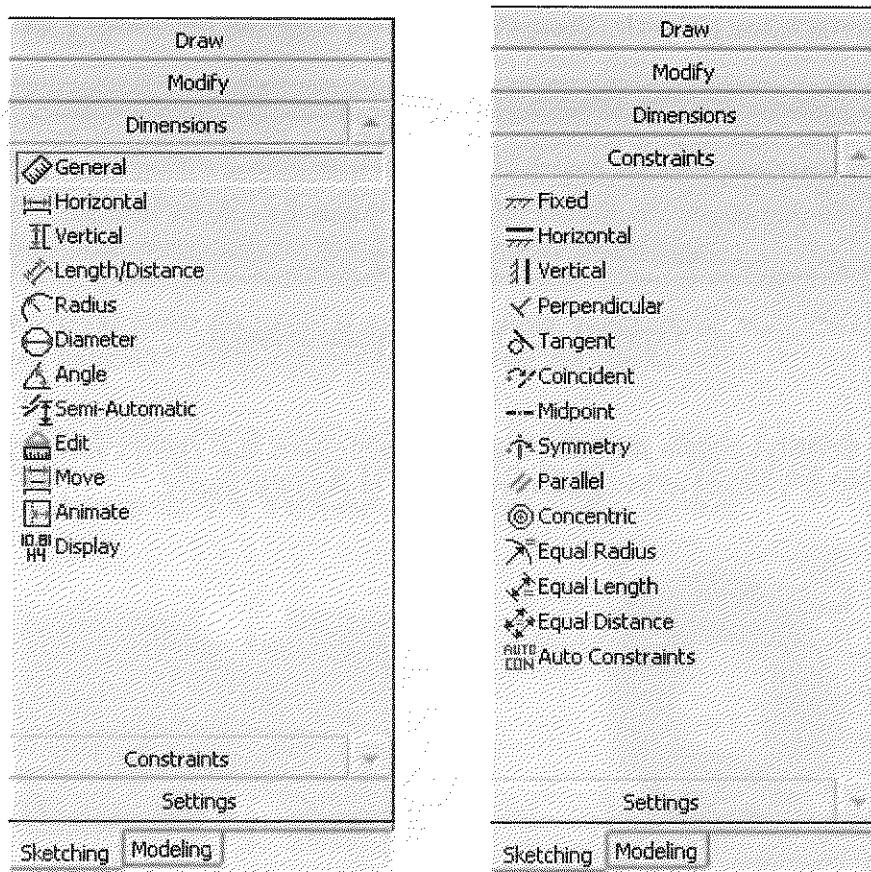


Figure 1-25 Dimension and Constraint sketching options.

Dimensioning is the process of defining how geometry is to be constructed.

In that regard, sketches must be **unambiguously** defined; that is, they cannot have too many dimensions or too few dimensions specified. The figure below shows two different dimensioning schemes for a simple shape.

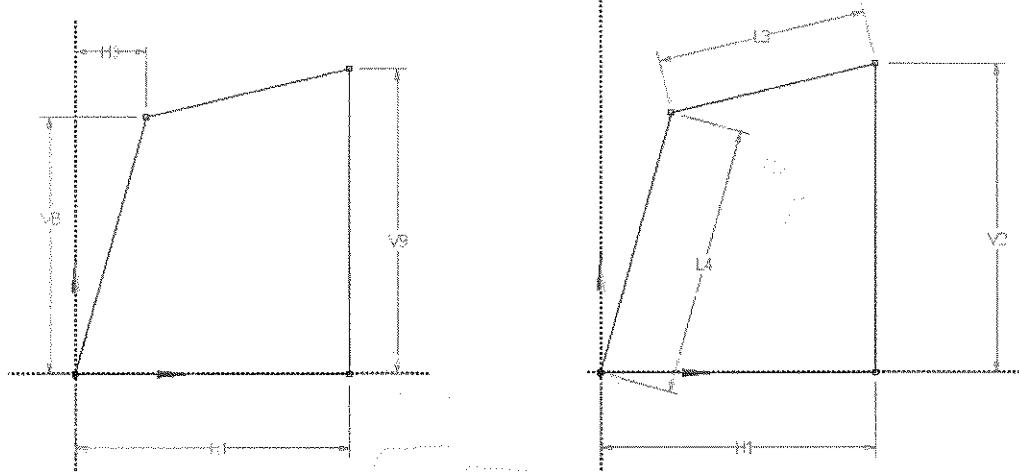


Figure 1-26 Two different dimensioning schemes.

If you over-dimension a sketch, DesignModeler will issue the following warning:

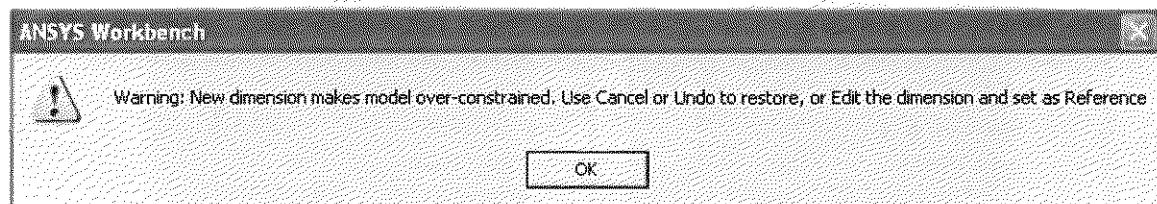


Figure 1-27 Over-constraint message.

Finally, the **Settings** option provides a **grid** sketching aid that allows you to create drawing entities placed at vertices of the grid as indicated in the next figure.

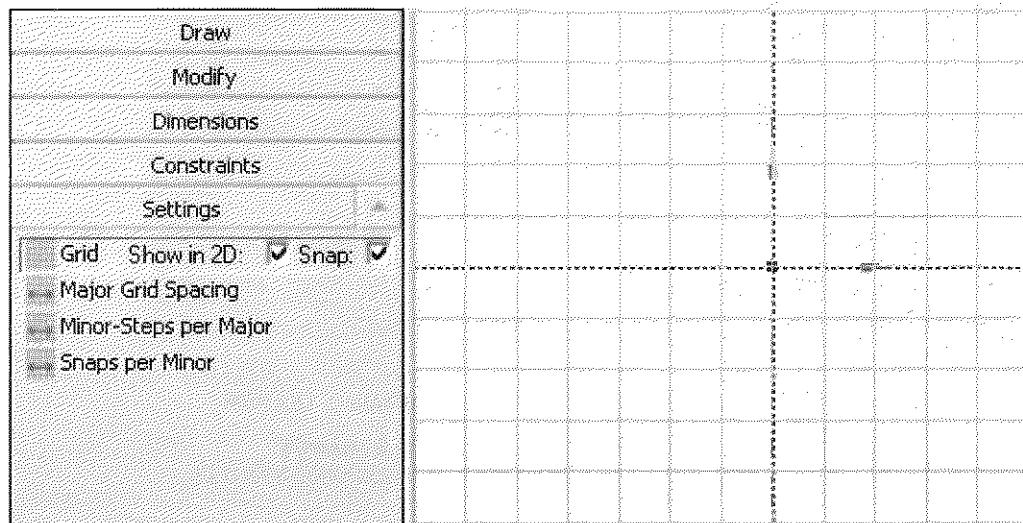


Figure 1-28 Settings options and a sketching grid.

## 1-7 SUMMARY

Three tutorials in Chapter 1 introduce basic solid model creation in ANSYS DesignModeler and provide examples from which more complex shapes can be developed. In the next chapter we will extend these ideas and introduce additional modeling features.