Basic Jewelry Modeling in Rhinoceros®
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Tutorials provided by:

Alex Antich, TechJewel

Giuseppe Massoni, Massoni Design
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1 Create a Ring with a Concave Top Surface

In this tutorial, you will learn how to make a ring with a concave top surface.

You will learn how to:

- Use grid snap and object snaps
- Use layers
- Make circles and arcs to define the shape of the ring
- Extend arcs
- Join the arc segments into a single polyline
- Offset a polyline to make a second polyline
- Turn on and move control points
- Extrude the 2-D curves to make solids
- Use zoom commands to change the view
- Use the BooleanDifference command to hollow the ring’s interior

Starting a Model with a Template

When starting a model in Rhino you can select a template to begin the modeling process. Templates contain information that helps you get started such as units, layers, viewport layouts, and toolbars.

Selecting a default template sets the units for your model. For these examples, we will be using millimeters as our units.

The templates include six predefined layers. Layers are a way of organizing objects so you can manipulate them separately or keep track of them in some way. It may help you to think of layers as transparent sheets where you can place different parts of your model. The predefined layers have color properties that will let you distinguish various parts more easily.

Modeling aids can help you draw the 2-D geometry with more precision. In this tutorial you will use the snap and object snap (osnap) modeling aids. You can find the controls for modeling aids on the status bar at the bottom of the Rhino window.

When Snap is on, the marker "snaps" between grid snap points. In this template, the grid snap is set at one-millimeter intervals to match the grid line intersections.

Object snaps make it easy to snap precisely to various parts of the geometry. In this tutorial, we will use the End object snap to attach geometry at the end of another piece of geometry.

Note Object snaps are crucial to accurate modeling. Never try to place things visually on the screen; it is too difficult, and it is impossible to ensure accuracy.
To start the model

- On the File menu, click New, select Millimeters.3dm, and then click Open.

To turn on modeling aids

- On the status bar, click the Snap and Osnap panes.

These controls are toggles. Click a pane once to turn the aid on; click again to turn it off. When modeling aids are turned on, the text in the pane is bold.

Clicking the Osnap pane toggles the display of the Osnap toolbar.

The Osnap pane text is bold only when one or more of the object snap check boxes are selected.

You will be using the Osnap toolbar in this tutorial, so make sure it is displayed.

Modeling the Shank Outline

We will start by making an outline of the shank. First, we will maximize the Front viewport to make it easier to see.

To maximize the Front viewport

- In the Front viewport, double-click the viewport title.

To make the inside of the shank

1. On the Curve menu, click Circle, and then click Center, Radius.

2. At the Center of circle ... prompt, move your mouse pointer to the origin of the viewport construction plane (where the red and green axis lines meet) and click.

Since grid snap is on, the cursor will snap exactly to the origin point where the axes meet.
3 At the **Radius** ... prompt, type 9, and press ENTER.

To make the outside of the shank

1 On the **Curve** menu, click **Arc**, and then click **Start, End, Point**.

2 At the **Start of arc** prompt, click a point **2 mm** (two grid lines) to the left of the left quadrant of the circle.

3 At the **End of arc** prompt, click a point **2 mm** to the right of the right quadrant of the circle.

4 At the **Point on arc** prompt, click a point **1 mm** from the bottom of the circle.
To make the top of the shank

1. On the Curve menu, click Arc, and then click Start, End, Point.

2. At the Start of arc prompt, click a point approximately 5 mm up from the top and 4 mm to the left of the top of the circle.

3. At the End of arc prompt, click a point 8 mm to the right of the start point.

4. At the Point on arc prompt, click a point 4 mm from the top of the circle.

To finish the curves for the shank

1. On the Osnap toolbar, select the End check box.

2. On the Curve menu, click Extend, and then click By Arc to a Point.

3. At the Select curve to extend ... prompt, click the upper left end of the arc that forms the bottom of the shank.
4 At the **End of extension ...** prompt, move your mouse pointer until the **End** object snap causes it to snap to the left end of the arc at the top and click.

5 **Repeat** steps 2 through 4 to extend the arc on the right side of the shank.
Creating the Inside Shank Curve

Next, we will offset the outside curve to make another curve that defines the inside of the shank.

To join the outside shank curves

1. On the Edit menu, click Join.
2. At the Select object to join prompt, click curve 1.
3. At the Select curve to join prompt, click curve 2.
   This will join the two curves into one polycurve.

To set the current layer

The Layer pane displays the name of the current layer. In this case, the Layer pane should display the layer name "Default."

- On the status bar, click the Layer pane, and then select the Layer 01 check box.

   This sets the current layer to Layer 01 so that the new offset curve will display in red, the color of Layer 01.

To offset the joined curve

1. Select the joined curve, if it is not already selected.
2. On the Curve menu, click Offset Curve.
3. At the ThroughPoint ... prompt, type .8, and press ENTER.
   This sets the offset distance to 0.8 mm.
4 At the ThroughPoint... prompt, click inside the selected curve.

A new curve is created 0.8 mm inside the original curve.
To edit the interior curve

1 Select the red offset curve.

2 On the Edit menu, click Control Points, and then click Control Points On.

   Control points appear surrounding the curve. These display as small squares. Control determine the shape of the curve.

3 Select the three control points at the bottom of the curve.

   To select the points individually, hold the SHIFT key and click.

   Another way to select the points is to click and drag a window from left to right that encloses the three points.

4 On the Transform menu, click Move.

5 At the Point to move from prompt, click a point in the center of the ring.

6 At the Point to move to prompt, click a point approximately 4 mm above the first point.

7 On the Edit menu, click Control Points, and then click Control Points Off.

   This is so the solid created from this curve that will be used to hollow the ring will not cut through the lower part of the band.
Extruding Curves to Create the Solid Ring

The next step is to make two extruded solids; one for the ring and another that will be used to cut out the inside of the shank. This operation will be easier to visualize if you can see all four viewports.

To restore the four-viewport layout

1. In the Front viewport, double-click the viewport title.
2. On the View menu, click Zoom, and then click Extents All.

   The view zooms in each viewport to display all of the geometry.
   You can also rotate the mouse wheel to zoom in and out in the active viewport.

To set the current layer

- On the status bar, click the Layer pane, and then select the Default check box.

   This sets the current layer to Default.

To extrude the shank curves

1. Select the outer curve and the original circle.
2. On the Solid menu, click Extrude Planar Curve, and then click Straight.
3. At the Extrusion distance ... prompt, move your mouse pointer to the command line and click the options so they are set as follows:
   - BothSides=Yes
   - Cap=Yes
   - Mode=Straight
   - DeleteInput=No
4. At the Extrusion distance ... prompt, type 4, and press ENTER.

   The curves are extruded 4 mm on either side of the original curves making ring surfaces 8 mm wide, and adding flat surfaces on the two sides to make a complete solid.
To shade the viewport

- In the **Perspective** viewport, right-click the viewport title, and then click **Shaded Display**.

To set the current layer

- On the **status bar**, click the **Layer** pane, and then select the **Layer 01** check box.

To extrude the interior curve

1. **Select** the interior curve.
2. On the **Solid** menu, click **Extrude Planar Curve**, and then click **Straight**.
3. At the **Extrusion distance ...** prompt, type **3**, and press ENTER.

   The options should be set as before:

   - BothSides=Yes
   - Cap=Yes
   - Mode=**Straight**
   - DeleteInput=No

Cutting Out the Shank

We will finish the ring by removing the extruded interior solid from the ring solid using a Boolean operation.

The three Boolean operations in Rhino are **Union**, **Difference**, and **Intersection**.

The **BooleanUnion** command merges two or more intersecting solids into one piece. The **BooleanDifference** command removes one or more solids from another. The **BooleanIntersection** command leaves only the intersecting part of two or more solids.
To remove the center from the ring

1. Select the ring solid.
2. On the Solid menu, click Difference.
3. At the Select second set of surfaces or polysurfaces ... prompt, click the interior solid, and press ENTER.

The smaller cutout solid is removed from the shank of the ring.

4. In the Perspective viewport, right-click and drag to rotate the view.
2 Create a Ring with Decorative Top Elements

In this tutorial you will learn how to make another style of ring.

In addition to practicing the techniques from the previous tutorial, you will learn how to:

- Use Ortho to draw at 90-degree increments.
- Use the Mirror command to model symmetrical objects.
- Use Fillet to make rounds between two curves.

Note: You should complete the tutorial in the previous chapter before starting this tutorial.

To start the model

- On the File menu, click New, select Millimeters.3dm, and then click Open.

To turn on modeling aids

1. On the status bar, click the Snap and Osnap panes.
2. On the status bar, click the Ortho pane.

When Ortho is on, cursor movement is restricted to points at multiples of a specified angle from the last point created. The default angle is 90 degrees.

Modeling the Shank

We will start by making the outline of the shank.

To maximize the Front viewport

- In the Front viewport, double-click the viewport title.

To make the inside of the shank

1. On the Curve menu, click Circle, and then click Center, Radius.
2 At the Center of circle ... prompt, move your mouse pointer to the origin of the viewport construction plane and click.

3 At the Radius ... prompt, type 9, and press ENTER.

To make the outside of the shank

1 On the Curve menu, click Arc, and then click Start, End, Point.

2 At the Start of arc prompt, click a point 2 mm (two grid lines) to the left of the left quadrant of the circle.

3 At the End of arc prompt, click a point 2 mm to the right of the right quadrant of the circle.
4 At the Point on arc prompt, click a point 1 mm from the bottom of the circle.

To finish the outside of the shank

1 On the Curve menu, click Line, and then click Single Line.

2 At the Start of line … prompt, set the BothSides option to Yes.
   This lets you make a line from a middle point with symmetry.

3 At the Middle of line… prompt, click a point 1 mm up from the top quadrant of the circle.

4 At the End of line prompt, type 9, and press ENTER.
   Typing a value and pressing ENTER sets a constraint for the length. The result is no matter where you click, the line will be 9 units from the middle point on both sides.
5 At the **End of line** prompt, move your mouse to the right and click.

The cursor movement is constrained to 90-degree angles by the Ortho setting and to 9 mm by the distance constraint.

---

**To make the top inside part of the shank oval**

1 **Select** the circle.

2 On the **Edit** menu, click **Control Points**, and then click **Control Points On**.

3 **Select** the three control points at the top of the circle.
4 On the **Transform** menu, click **Move**.

5 At the **Point to move from** prompt, click the point at the top of the circle.

6 At the **Point to move to** prompt, click the middle of the line.

7 On the **Edit** menu, click **Control Points**, and then click **Control Points Off**.

**To finish the curves for the shank**

1 On the **Osnap** toolbar, select the **End** check box.

2 On the **Curve** menu, click **Extend**, and then click **By Arc to a Point**.

3 At the **Select curve to extend** ... prompt, use the **End** object snap to select the upper left end of the arc that forms the bottom of the shank.

4 At the **End of extension** prompt, use the **End** object snap to select the left end of the line at the top and click.

5 **Repeat** these steps to extend the arc on the right side of the shank.

**To make the center arc for the top of the ring**

1 On the **Curve** menu, click **Line**, and then click **Single Line**.

2 At the **Start of line** ... prompt, set the **BothSides** option to **Yes**.

3 At the **Middle of line**... prompt, click a point **3 mm** above the top quadrant of the oval.

4 At the **End of line** prompt, type **4**, and press ENTER.
5 At the End of line prompt, move your mouse pointer to the right and click.

6 On the Curve menu, click Arc, and then click Start, End, Direction.

7 At the Start of arc prompt, snap to one end of the line and click.

8 At the End of arc prompt, snap to other end of the line and click.

9 At the Direction at start prompt, click a point directly above the first point.

To make the side arcs

1 On the status bar, click the Ortho pane to toggle Ortho off.

2 On the Curve menu, click Arc, and then click Start, End, Direction.

3 At the Start of arc prompt, use the End object snap to start the arc at the left corner of the shank.

4 At the End of arc prompt, use the End object to end the arc at the left end of the upper arc.

5 At the Direction at start prompt, drag and click to make the arc as illustrated.

To mirror the arc to the other side

1 Turn Ortho on.
2 Select the arc you just created.

3 On the Transform menu, click Mirror.

4 At the Start of mirror plane ... prompt, click in the center of the ring.

5 At the End of mirror plane ... prompt, use Ortho to click directly above the first point.

6 Select the two construction lines, and press DELETE.

To make a radius between the arcs

1 On the Curve menu, click Fillet Curves.

2 At the Select first curve to fillet ... prompt, type .2, and press ENTER.
   This sets the fillet radius to 0.2.

3 At the Select first curve to fillet ... prompt, click the Join option.
   This joins the arcs at the same time it makes the round.
   Check the options to see that they are set as follows:
   Radius=0.2
   Join=Yes
   Trim=Yes
   DeleteInput=No
4 At the **Select first curve to fillet** ... prompt, click near the end of one of the arcs (1).

5 At the **Select second curve to fillet** ... prompt, click near the end of the adjacent arc.

Another arc is drawn between the arcs, the original arcs are trimmed back to the ends of the fillet, and the three parts are joined.

6 **Repeat** this step for the other side (2).
Creating the Inside Curve

Next we will make a copy of the outside of the ring to use to cut out the inside of the shank.

To make the curve that defines the inside of the shank

1. Select all the curves that form the outer part of the ring.
2. On the Edit menu, click Join.
   This will join the curves into one polyline.

To set the current layer

On the status bar, click the Layer pane, and then select the Layer 01 check box.

To offset the curve

1. Select the joined curve.
2. On the Curve menu, click Offset Curve.
3. At the ThroughPoint ... prompt, type .8, and press ENTER.
4. At the ThroughPoint ... prompt, click inside the selected curve.
A new curve is created 0.8 mm inside the original curve.

**To adjust the curve to move the lower part out of the way of the band**

1. **Select** the offset curve you just created.

2. On the **Edit** menu, click **Control Points**, and then click **Control Points On**.

3. **Select** the three control points at the bottom of the curve.
4 On the **Transform** menu, click **Move**.

5 At the **Point to move from** prompt, click a point at the bottom of the curve.

6 At the **Point to move to** prompt, click a point approximately **4 mm** above the first point.

7 On the **Edit** menu, click **Control Points**, and then click **Control Points Off**.

---

**Extruding Curves to Create the Solid Ring**

The next step is to make two solid extrusions; one for the ring and another for the inside of the shank. This section will be easier if you can see all four viewports.

**To restore the four-viewport layout**

1 In the **Front** viewport, double-click the viewport title.

2 On the **View** menu, click **Zoom**, and then click **Extents All**.

**To set the current layer**

- On the **status bar**, click the **Layer** pane, and then select the **Default** check box.

  This sets the current layer to Default.

**To extrude the shank curves**

1 **Select** the outer curve and the circle.

2 On the **Solid** menu, click **Extrude Planar Curve**, and then click **Straight**.

3 At the **Extrusion distance** ... prompt, move your mouse pointer to the command line and click the options so they are set as follows:

   - **BothSides** = Yes
   - **Cap** = Yes
   - **Mode** = Straight
   - **DeleteInput** = No
At the Extrusion distance ... prompt, type 4, and press ENTER.

The curves are extruded 4 mm on either side of the original curve giving the ring a thickness of 8 mm.

To set the current layer

- On the status bar, click the Layer pane, and then select the Layer 01 check box.

To extrude the interior curve

1. Select the interior curve.
2. On the Solid menu, click Extrude Planar Curve, and then click Straight.
3. At the Extrusion distance ... prompt, type 3, and press ENTER.

The options should be set as before:

- BothSides=Yes
- Cap=Yes
- Mode=Straight
- DeleteInput=No
Cutting Out the Shank

We will finish the ring by removing the extruded interior solid from the ring solid using a Boolean operation.

**To remove the center from the ring**

1. **Select** the ring extrusion.
2. On the **Solid** menu, click **Difference**.

3. At the **Select second set of surfaces or polysurfaces ...** prompt, select the interior solid.

4. At the **Select second set of surfaces ...** prompt, press ENTER.

   The smaller extrusion is removed from the shank of the ring.
3 Create a Simple Band Ring

In this tutorial you will learn how to make a simple band ring with scallop detailing.

In addition to practicing the techniques you learned in the previous chapters, you will learn how to:

- Make a surface with a 1 Rail Sweep

**Note**: You should complete the tutorials in the previous chapters before starting this tutorial.

To start the model

- On the **File** menu, click **New**, select **Millimeters.3dm**, and then click **Open**.

To turn on modeling aids

- On the **status bar**, click the **Snap**, **Ortho**, and **Osnap** panes.

**Modeling the Shank Inner Curve**

We will start by making an outline of the shank.

**To maximize the Front viewport**

- In the **Front** viewport, double-click the viewport title.

**To make the inside of the shank**

1. On the **Curve** menu, click **Circle**, and then click **Center, Radius**.
2 At the **Center of circle** prompt, move your mouse pointer to the origin of the viewport construction plane (where the red and green axes lines meet) and click. Since grid snap is on, the cursor will snap exactly to the origin point where the axes meet.

3 At the **Radius** prompt, type 9, and press ENTER.

---

**To make a reference point on the circle**

1 On the **Osnap** toolbar select the **End, Point**, and **Quad** check boxes.

2 On the **Curve** menu, click **Point Object**, and then click **Single Point**.

3 At the **Location of point object** prompt, use the **Quad** object snap to place the point at the top quadrant of the circle. This will give us a reference point for creating the cross-section of the band.
Creating the Shank Cross-Section Profile

In this section you will create the cross-section profile curve that will be swept around the shank curve.

To maximize the Right viewport

1. In the Front viewport, double-click the viewport title to restore the four-viewport layout.
2. In the Right viewport, double-click the viewport title.

To make the construction lines for the cross-section curve

1. On the Curve menu, click Line, and then click Single Line.
2. At the Start of line ... prompt, click BothSides.
3. At the Middle of line ... prompt, click the reference point you created in the previous section.
4. At the End of line prompt, type 5, and press ENTER.
5. At the End of line prompt, move your mouse to the right and click.
   The cursor movement is constrained to 90-degree angles by the Ortho setting and to 5 mm by the distance constraint.

6. On the Curve menu, click Line, and then click Single Line.
7. At the Start of line... prompt, click the left end of the line you just created.
8. At the End of line prompt, type 1, and press ENTER.
9  At the **End of line** prompt, click directly above the first point.

To create the first arc

1  On the **Curve** menu, click **Arc**, and then click **Start, End, Direction**.

2  At the **Start of arc** prompt, use the **End** object snap to start the arc at the upper end of the line you just created.

3  At the **End of arc** prompt, move your mouse pointer two grid points to the right and click.

4  At the **Direction at start** prompt, click a point directly above the first point.

To mirror the arc and the line segment

1  **Select** the arc and the vertical line segment you just created.

2  On the **Transform** menu, click **Mirror**.

3  At the **Start of mirror...** prompt, snap to the reference point.
4 At the **End of mirror plane...** prompt, click directly above the first point.

**To finish the cross-section curve**

1 On the **Curve** menu, click **Arc**, and then click **Start, End, Point**.

2 At the **Start of arc** prompt, use the **End** object snap to start the arc at the end of one of the side arcs.

3 At the **End of arc** prompt, use the **End** object snap to end the arc at the end of the other arc.

4 At the **Point on arc** prompt, click a point **2 mm** up from the reference point.
To join the cross-section curve

1 Select the three line segments and the three arcs.
2 On the Edit menu, click Join.

To restore the four viewport layout

- In the Right viewport, double-click the viewport title.

To finish the band ring

1 On the Surface menu, click Sweep 1 Rail.
2 At the Select rail curve prompt, click the circle (1).
3 At the Select cross section curves ... prompt, click the cross-section you just created (2), and press ENTER.
4 In the Sweep 1 Rail Options dialog box, click OK.
4 Create an Eternity Ring with Claw Settings

In this tutorial, you will learn how to make a ring with a specified number of elements evenly spaced around the shank of the ring. The ring we will make will have twenty-two elements.

In an eternity ring you usually have the problem of matching the size and a specific number of stones, or you may have a constraint given by the size of the stones. The polar array command will solve this problem.

A polar array is a repetition of items around a center where you can specify the number of elements and the angle to fill.

In addition to practicing techniques you learned in the previous chapters, you will learn how to:

- **Array** objects around a circle
- **Trim** and **chamfer** curves
- Make a **revolved** surface

**Note:** You should complete the tutorials in the previous chapters before starting this tutorial.

**To start the model**

- On the **File** menu, click **New**, select **Millimeters.3dm**, and then click **Open**.

**To turn on modeling aids**

- On the **status bar**, click the **Snap** and **Osnap** panes.

**Modeling the Shank**

We will start by making an outline of the shank.

**To maximize the Front viewport**

- In the **Front** viewport, double-click the viewport title.

**To make the inside of the shank**

1. On the **Curve** menu, click **Circle**, and then click **Center**, **Radius**.
2 At the **Center of circle...** prompt, move your mouse pointer to the origin of the viewport and click.

3 At the **Radius ...** prompt, type 9, and press ENTER.

**Create the Claw to Array**

Next we will make a copy of the inside of the ring to use for a construction curve for the outer part of the ring.

**Create a construction circle for the outside of the shank**

The construction circle provides the outer boundary of the arrayed elements.
To create the construction circle

1. **Select** the circle you just created.
2. On the **Curve** menu, click **Offset Curve**.
3. At the **Through point ...** prompt, type .2, and press ENTER.
4. At the **Through point ...** prompt, click outside the first circle.

Create construction lines

Next, we will make the rest of the construction lines for the claw elements. We will start by making a single line and arraying around the circle 22 times. This will give us the proper spacing for the elements. The spacing is determined by the number of stones that will be placed in the ring.

To make a construction line

1. On the **Osnap** toolbar, select the **Cen** check box.
2. On the **Curve** menu, click **Line**, and then click **Single Line**.
3. At the **Start of line ...** prompt, move your mouse pointer over one of the circles, and click when the **Cen** osnap tooltip appears.
4. At the **End of line ...** prompt, click a point 2 mm to the right of the right quadrant of the outer circle.

To array the construction line in a circle

1. **Select** the line you just created.
2. On the **Transform** menu, click **Array**, and then click **Array Polar**.
3. At the **Center of polar array** prompt, snap to the center of the circles.
4. At the **Number of items ...** prompt, type 22, and press ENTER.
5 At the **Angle to fill <360>** prompt, press ENTER to accept the default value.

---

**To delete the unnecessary lines**

Now that the spacing for the elements has been established by the array, you can delete all but the two lines that you will use to construct the claw feature.

- Select all of the lines except the two that are located at either side of the top of the circle, and press DELETE.

---

**To make the construction curves for the starting element**

1 On the Osnap toolbar, select the **Quad** check box, and clear the **Cen** check box.

2 On the Curve menu, click **Circle**, and then click **Center, Radius**.
3  At the **Center of circle** ... prompt, use the **Quad** osnap to place the center of the circle at the top quadrant of the outside construction circle.

4  At the **Radius** ... prompt, type **.8**, and press ENTER.

5  **Select** the three circles and two lines.

6  On the **Edit** menu, click **Trim**.

7  At the **Select object to trim** prompt, click the tops of the two lines, the left and middle of the outside circle, and the top of the small circle, and press ENTER.

   The point on the curve you pick determines the part that will be removed.

   The result should match the illustration.

**To chamfer the edges of the starting element**

1  On the **Curve** menu, click **Chamfer Curves**.

2  At the **Select first curve to chamfer** ... prompt, click **Distances**.

3  At the **First chamfer distance** ... prompt, type **.4**, and press ENTER.
4 At the **Second chamfer distance** ... prompt, type .4, and press ENTER.

5 At the **Select first curve to chamfer** ... prompt, click on the line (1).

6 At the **Select second curve to chamfer** ... prompt, click the arc segment (2).

7 **Repeat** these steps to chamfer the line and the arc segment on the right side.

8 **Delete** the left and right construction lines.

9 **Select** the four remaining lines and arcs.

10 On the **Edit** menu, click **Join**.
Arraying the Claw Profile Around the Ring

Next we will array the single claw feature around the ring.

To array the claw profile

1. On the Osnap toolbar, select the Cen check box, and clear the Quad check box.
2. Select the joined curves you just created.
3. On the Transform menu, click Array, and then click Array Polar.
4. At the Center of polar array prompt, snap to the center of the circle.
5. At the Number of items <22> prompt, press ENTER.
6. At the Angle to fill <360> prompt, press ENTER.

Extruding the Curves to Create the Solid Ring

The next step is to extrude the inside and the outside curves to form the main part of the band. This section will be easier if you can see all four viewports.

To restore the four-viewport layout

1. In the Front viewport, double-click the viewport title.
2. On the View menu, click Zoom, and then click Extents All.
To extrude the shank curves

1. Set the current layer to **Layer 01**.
2. **Select** the claw curves and the circle.
3. On the **Solid** menu, click **Extrude Planar Curve**, and then click **Straight**.
4. At the **Extrusion distance ...** prompt, click **BothSides**.

5. At the **Extrusion distance ...** prompt, type **1.5**, and press **ENTER**.
   
   The curves are extruded 1.5 mm on either side of the original curves giving the ring a thickness of 3 mm.

Creating the Channel

The next step is to make a revolved surface to cut out a channel in the outside of the ring.

To make the construction curves for the channel

1. Set the current layer to **Default**.
2. On the **Curve** menu, click **Circle**, and then click **Center, Radius**.
3 At the **Center of circle** ... prompt, use the Cen object snap to start the circle at the center of the shank circle.

4 At the **Radius** ... prompt, type **11.5**, and press ENTER.

5 On the Osnap toolbar, select the **Quad** check box, and clear the **Cen** check box.

6 On the **Curve** menu, click **Circle**, and then click **Center, Radius**.

7 At the **Center of circle** ... prompt, in the Right viewport, use the **Quad** object snap to the circle quadrant at the top of the construction circle you just created.

8 At the **Radius** ... prompt, type **1**, and press ENTER.

---

**To make the revolved surface**

1 Turn **Ortho** on.

2 **Select** the circle you just created.

3 On the **Surface** menu, click **Revolve**.

4 At the **Start of revolve axis** prompt, type **0**, and press ENTER.

   This sets start point at the construction plane origin.
5 At the **End of revolve axis** prompt, move your mouse pointer to the **Perspective** viewport, and then along the world y-axis and click.

A tubular surface is created around the circumference of the ring.

---

**Cut the Channel**

We will finish the ring by using the revolved surface to cut a channel in the ring.

**To cut the channel**

1. **Select** the ring solid.
2. On the **Solid** menu, click **Difference**.
3 At the **Select second set of surfaces or polysurfaces** ... prompt, select the revolved surface, and press ENTER.

The revolved surface is removed from the outside of the ring.
5 Create a Ring with Gemstones

In this tutorial you will learn how to make another style of extruded ring.

In addition to practicing the techniques you learned in the previous chapters, you will learn how to:

- **Import** a model to add pre-made features
- **Rotate** an object
- **Copy** curves
- Add control points to a curve by inserting knots
- **Hide** curves
- Make a surface lofted between curves
- Make surfaces from planar curves
- Use a sweep a curve along two rail curves to make surfaces
- **Join** surfaces into a closed polysurface

**Note:** You should complete the tutorials in the previous chapters before starting this tutorial.

To start the model

- On the **File** menu, click **New**, select **Millimeters.3dm**, and then click **Open**.

To turn on modeling aids

- On the **status bar**, click the **Snap** and **Osnap** panes.

Draw the Initial Shank Outline Shape

We will start by making an outline of the shank.

To maximize the Front viewport

- In the **Front** viewport, double-click the viewport title.
To make the inside of the shank

1. On the Curve menu, click Circle, and then click Center, Radius.

2. At the Center of circle ... prompt, move your mouse pointer to the origin of the viewport and click.

3. At the Radius ... prompt, type 9, and press ENTER.

To make the outside of the shank

1. On the Curve menu, click Arc, and then click Start, End, Point.

2. At the Start of arc prompt, click a point 2 mm (two grid lines) to the left of the left quadrant of the circle.

3. At the End of arc prompt, click a point 2 mm to the right of the right quadrant of the circle.
4  At the **Point on arc** prompt, click a point **1 mm** from the bottom of the circle.

---

**Adding Gemstones**

Because the size of the ring depends on the size and number of gemstones, the next step is to insert a model of a stone. We will then scale and position the stone and copy it. The rest of the model will be created around the size and position of the stones.

**Importing a gemstone model**

Before importing a gemstone model, we will make a reference point to make placing the stone easier.

**To make a reference point for inserting the stone**

1  On the **Curve** menu, click **Point Object**, and then click **Single Point**.

2  At the **Location of point object** prompt, click a point **4 mm** above the top of the circle.

3  On the **Osnap** toolbar, select the **Point** check box, and clear all other check boxes.

Since the gemstone model we are inserting is exactly one unit (millimeter) square, we can scale it when we insert it. We want to have a stone that is **5 mm square** and **5 mm** high.
To insert the stone

1. On the **File** menu, click **Insert**.
2. On the **Insert** dialog box, click **File** and navigate to the folder where you saved these tutorial files, and select **Square_05.3dm**.
3. Under **Insertion point**, select the **Prompt** check box.
4. Under **Scale**, select the **Uniform** check box, in the **X** box type **5.0**, and click **OK**.
5. At the **Insertion point** prompt, in the **Top** viewport, use the Point object snap to place the stone at the point object you just created.

Place another gemstone

For the next gemstone, you will copy and rotate your original gemstone model.

To copy the stone

1. Maximize the **Perspective** viewport.
2. **Select** the stone you just inserted.
3. On the **Transform** menu, click **Copy**.
4 At the **Point to copy from** prompt, use the **End** object snap to start at the lower left end of the stone (1).

5 At the **Point to copy to** prompt, use the **End** object snap to end at the lower right end of the stone (2).

---

**To rotate the stone**

1 **Maximize** the **Front** viewport.

2 **Select** the stone you just copied.

3 On the **Transform** menu, click **Rotate**.

4 At the **Center of rotation ...** prompt, use the **End** object snap to click the lower left end of the selected stone, as illustrated (1).

5 At the **Angle or first reference ...** prompt, move your mouse pointer to the right and click.

6 Turn **Ortho** off.
   - Or -
   - Hold **SHIFT** to suspend Ortho for the next mouse click.

7 At the **Second reference ...** prompt, move your mouse pointer down slightly and click.

---

**Place the third gemstone**

You will now mirror the second gemstone around the center of the ring to create a third gemstone. In addition to the gemstone, we want to create a small construction line that will help define the edge of the mounting. You will also mirror this line to the other side to make the setting symmetrical.

---

**To make a construction line to help define the ring edge**

1 Turn **Ortho** on.

2 On the **Curve** menu, click **Line**, and then click **Single Line**.
3 On the Osnap toolbar, click Project.

The Project object snap mode projects the object snap point to the construction plane. When you start the line using the End object snap, instead of snapping to the corner of the stone, the snap point is projected to the construction plane and the line will start at the center of the stone's edge where the construction plane and the stone intersect.

4 At the Start of line ... prompt, use the End object snap projected to the construction plane to start the line at the right edge of the stone as illustrated.

5 At the End of line prompt, type 1.4, and press ENTER.

6 At the End of line prompt, move your mouse to the right and click.

To mirror the stone and the construction line

1 Select the copied stone and the line you just created.

2 On the Transform menu, click Mirror.

3 At the Start of mirror plane ... prompt, use the Cen object snap to start the mirror plane at the center of the ring.

4 At the End of mirror plane ... prompt, use Ortho to click directly above the first point.
Making the Finished Shank Curves

We can now add the curves that define the shape of the interior and exterior of the shank.

To create the lower outside edge curve

1. On the Curve menu, click Extend, and then click By Arc to a Point.
2. At the Select curve to extend ... prompt, click the upper left end of the arc that will form the bottom of the shank.
3. At the End of extension ... prompt, use the End object snap to end the arc extension at the left end of the top arc.
4. Repeat this command to extend the arc on the right side of the shank.

To make an arc that defines the shape at the top

1. Turn Ortho off.
2. On the Curve menu, click Arc, and then click Start, End, Direction.
3. At the Start of arc ... prompt, use the End object snap to start the arc at the top left end of the arc you just created.
4. At the End of arc ... prompt, use the End object snap to end the arc at the top right end of the arc you just created.
5 At the **Direction at start ...** prompt, move your mouse pointer up until the curve roughly follows the profile of the stones as shown and click.

---

**Making the Interior Opening**

Next we will make a copy of the outside of the ring to use to cut out the inside of the shank and the opening for the stones in the top of the ring.

**To make the curve that defines the inside of the shank**

1 Set the current layer to **Layer 01**.
2 **Select** the curve that forms the outer part of the ring.
3 On the **Curve** menu, click **Offset Curve**.
4 At the **ThroughPoint ...** prompt, type **.8**, and press ENTER.
5 At the **ThroughPoint ...** prompt, click inside the selected curve.
To edit the curve shape

1 Select the offset curve.
2 On the Edit menu, click Control Points, and then click Control Points On.
3 Select the three control points at the bottom of the curve.
4 On the Transform menu, click Move.
5 At the Point to move from prompt, click a point in the center of the ring.
6 At the Point to move to prompt, click a point approximately 4 mm above the first point.

Edit the interior curve’s shape

To make adjustment to the upper part of the offset curve without changing the lower part of the curve, it will be necessary to add additional control points.

One way to add control points to the curve with control over their position, is to add knots to the curve. For each knot we add, a control point will also be added.

**Note:** A knot is property of the curve where the mathematical definition of the curve changes. Imagine a rope. If you hold it at the ends, the rope will sag according to the laws of nature (gravity, the stiffness of the rope, etc.) with a mathematical definition. If you tie it off somewhere along its length (by putting knots in it), there will be a different definition (sag) for each segment between the knots.

To add control points

1 On the Edit menu, click Control Points, and then click Insert Knot.
2 At the Point on curve to add knot ... prompt, click approximately half way between the two uppermost control points on the offset curve.
3 At the Point on curve to add knot ... prompt, click approximately half way between the inserted knot and the next control point down the offset curve.

4 At the Point on curve to add knot ... prompt, press ENTER to end the command.

   The new control points will not be visible until the InsertKnot command has ended.

5 Drag the control points to match the illustration at the right.

   It is important that the vertical segment at the top intersects the edge of the stone.

6 On the Edit menu, click Control Points, and then click Control Points Off.

To create the other side of the curve

Since it would be difficult to repeat the previous steps exactly to make the other side of the curve symmetrical, the next two steps demonstrate how to make the curve symmetrical on each side of the ring.

1 Turn Ortho on.

2 On the Curve menu, click Line, and then click Single Line.

3 At the Start of line ... prompt, type 0, and press ENTER.

   This starts the line at the construction plane origin.

4 At the End of line prompt, move your mouse down and click.

   Make sure your line intersects the offset curve.
To trim the offset curve

1 Select the line you just created.
2 On the Edit menu, click Trim.
3 At the Select object to trim prompt, click the right side of the offset curve.
4 At the Select object to trim prompt, press ENTER to end the command.

To mirror the curve

1 Select the trimmed offset curve.
2 On the Transform menu, click Mirror.
3 At the **Start of mirror plane ...** prompt, use the **Cen** object snap to start the mirror plane in the center of the ring.

4 At the **End of mirror plane ...** prompt, use the **End** object snap to end the mirror plane at the end of the offset curve.

To make the closed solid you will use to cut out the interior of the ring, connect the two arcs with a line and join these pieces.

**To close the curves**

1 On the **Curve** menu, click **Line**, and then click **Single Line**.

2 At the **Start of line ...** prompt, use the **End** object snap to start the line at the end of the offset curve.

3 At the **End of line** prompt, use the **End** object snap to end the line at the end of the mirrored curve.

4 **Select** the line you just created and the two offset curves.

5 On the **Edit** menu, click **Join**.

**Making the Curves that Define the Exterior Shape**

The next step is to make copies of the curves you created. Then you will make construction curves to be used to make surfaces. Working in the Perspective viewport will make this step easier to complete.

**To set the layer**

1 Set the current layer to **Default**.

2 Turn **Layer 01** off.
To copy the shank curves

1. Select the outer curve, the circle, and the curve for the top.
2. On the Transform menu, click Copy.
3. At the Point to copy from prompt, type 0, and press ENTER.
4. At the Point to copy to prompt, type 3.7, and press ENTER.
5. At the Point to copy to prompt, move your mouse pointer along the y-axis and click.
6. At the Point to copy to prompt, type 3.7, and press ENTER.
7. At the Point to copy to prompt, move your mouse pointer the opposite direction along the y-axis and click.
8. At the Point to copy to prompt, press ENTER to end the command.
9. With the original curves still selected, from the Edit menu, click Visibility, and then click Hide.

   This will remove the original curves from the view.

To make a cross-section curve for the side and top surfaces or the ring

1. Turn Ortho off.
2. On the status bar click Planar.

   Planar mode aids in creating planar objects with commands that allow free picking. Successive pick points will have the same construction plane elevation as the first point.
3 On the Osnap toolbar, click **Project**.

   This will turn Osnap projection mode off, letting you to snap to the ends of the curves you copied, which are not on the construction plane.

4 On the Curve menu, click **Arc**, and then click **Start, End, Direction**.

   To make the curve, it will be necessary to move your mouse pointer between the Perspective viewport and the Top viewport while picking points.

5 At the **Start of arc** ... prompt, in the Perspective viewport use the End object snap to start the arc at the top right end of one of the curves you copied.

6 At the **End of arc** ... prompt, in the Perspective viewport, use the End object snap to end the arc click top right end of the other curve you copied.

7 At the **Direction at start** ... prompt, move your mouse pointer to the Top viewport, drag the arc shape, and click to approximate the direction illustrated.

**To rotate the cross-section curve**

1 **Select** the curve you just created.

2 On the Transform menu, click **Rotate**.
3 At the **Center of rotation** ... prompt, in the **Front** viewport, use the **End** object snap to place the center of rotation at the end of the arc.

4 At the **Angle or first reference point** ... prompt, move your mouse pointer to the right and click.

5 At the **Second reference point** ... prompt, move your mouse pointer up to approximate the direction illustrated.

---

To mirror the cross-section curve

1 Turn **Ortho** on.

2 **Select** the curve you just created.

3 On the **Transform** menu, click **Mirror**.

4 At the **Start of mirror plane** ... prompt, type 0, and press ENTER.

5 At the **End of mirror plane** ... prompt, use **Ortho** to move your mouse pointer up and click.
Making the Exterior Surfaces

The next step is to make the surfaces for the outside of the shank and the top of the ring.

To make the surface for the outside of the shank

1. Set the current layer to Layer 02.
2. Select the two curves that form the shank.
3. On the Surface menu, click Sweep 2 Rails.
4. At the Select cross section curves ... prompt, click one of the cross-section arcs you just created.
5. At the Select cross section curves ... prompt, select the other arc you just mirrored, and press ENTER.
6. In the Sweep 2 Rail Options dialog box, click OK.

To make the surface for the top of the ring

1. Select the two curves at the front and back of the top that run along the sides of the gems.
2. On the Surface menu, click Sweep 2 Rails.
3. At the Select cross section curves ... prompt, click the two top edges of the surface you just created.
4. At the Select cross section curves ... prompt, press ENTER.
In the Sweep 2 Rail Options dialog box, click OK.

Making the Interior Surface

The next step is to make a surface for the inside of the shank.

To make the lofted surface

1. Select the two circles.
2. On the Surface menu, click Loft.
3. At the Adjust curve seams ... prompt, press ENTER.

4. In the Loft Options dialog box, click OK.
Making the Front and Back Surfaces
The next step is to make a planar surface for the front and back of the ring.

To make the planar surface

1. On the Surface menu, click Planar Curves.
2. At the Select planar curves to build surface prompt, select the three surface edges at the front of the ring.
3. At the Select planar curves to build surface ... prompt, press ENTER.
4. Repeat these steps for the back of the ring.

To join the surfaces into one closed polysurface

1. Select all five surfaces.
2. On the Edit menu, click Join.
Making a Solid to Cut the Opening in the Top Surface

The next step is to make an extruded surface to cut out part of the outside of the ring.

To extrude the curve

1. Set the current layer to Layer 01, and turn the Default layer off.
2. Select the curve that defines the interior shape.
3. On the Solid menu, click Extrude Planar Curve, and then click Straight.
4. At the Extrusion Distance ... prompt, click the BothSides option.
   
   Set the options as follows:
   
   BothSides=Yes
   Cap=Yes
   Mode=Straight
   DeleteInput=No

5. At the Extrusion Distance ... prompt, in the Top viewport, adjust the thickness until it is slightly smaller than the height of the stones, and click.
Cut the Opening in the Top Surface

We will finish the ring by removing the extruded solid from the ring using a Boolean operation.

To hollow out the ring

1 Select the ring extrusion.

2 On the Solid menu, click Difference.

3 At the Select second set of surfaces or polysurfaces ... prompt, select the extruded solid you just created.