**Advanced Surfaces**

**Introduction**

Several advanced surface types are available as listed below.

**Variable Section Sweep**
A surface is created by sweeping a single section along one or more trajectories. The section can vary along the trajectory.

**Boundary Blend**
A surface is created by selecting existing curves to define the boundaries of the geometry.

**Section to Surfaces Blend**
A surface is created by blending from an existing set of tangent surfaces to a sketched section.

**Surface to Surface Blend**
A surface is created by blending between two existing surfaces.

The icons for the variable section sweep and the boundary blend are shown below. The other two surface types listed on this page do not have icons associated with them and must be created using the **Insert, Advanced** menu.

![Variable Section Sweep](image1)
![Boundary Blend](image2)

![Variable Section Sweep](image3)
![Boundary Blends](image4)
**Variable Section Sweep**

The **Variable Section Sweep** feature sweeps a single section along one or more trajectories. The section’s dimensions can vary as the section travels along the trajectories. The trajectories must be selected from existing datum curves. There are three types of variable section sweeps:

- Normal to Trajectory (see page 101).
- Normal to Projection (see page 102).
- Constant Normal Direction (see page 102).

Regardless of the type, every variable section sweep requires at least one ‘origin’ trajectory. In addition, each type has a special system parameter assigned to the trajectory, called `trajpar` (see page 103. When using this feature type, you have the choice of creating ‘surface’ or ‘solid’ geometry.

Several examples of variable section sweeps are shown below.
**The Variable Section Sweep Tool**

The **Variable Section Sweep** dashboard tool is used to create all types of variable section sweep features including solids, thins, surfaces, protrusions, and cuts. Pick Insert, Variable Section Sweep or pick the icon shown above. The **Variable Section Sweep** dashboard tool is shown below.

- Solid or Surface
- Define the Sketch
- Protrusion or cut
- Create Thin
- Make the section variable or constant in the **Options** panel
- The **References** panel contains all the references for the feature
- Set the section behavior here
- Use the right mouse button popup menu for shortcuts
Normal to Trajectory

When using the *Normal To Trajectory* option, the ‘origin trajectory’ and at least one additional trajectory is required. The section remains normal (perpendicular) to the selected trajectory as it sweeps.

Any number of additional trajectories can be selected, which are used to control the section’s vertices. As the section plane is swept along the trajectories, its intersection with the longitudinal trajectories represents ‘known points’ for section dimensioning and alignment. When a section vertex is dimensioned or aligned to an additional trajectory, the curve represents the trajectory of the section vertex.

When using the “Normal to (Origin) Trajectory” option, the section stays perpendicular to the origin trajectory as it passes along the origin trajectory.

When using the “Normal to (Other) Trajectory” option, the section stays perpendicular to the selected trajectory as it passes along the origin trajectory.
Normal to Projection

Variable section sweeps can be defined by using the **Normal to Projection** option. This option creates a sweep where the section’s Y-axis remains normal (perpendicular) to a selected plane while the X-axis and Z-axis follow the spine’s trajectory. For example, rather than sketching a spine and X-vector trajectory to create the feature, a single trajectory and plane can be used.

When using the “Normal to Projection” option, the section stays perpendicular to the selected plane as it passes along the origin trajectory.

Constant Normal Direction

When using the **Constant Normal Direction** option, the section is swept parallel to the selected plane as shown below.

When using the “Constant Normal Direction” option, the section stays parallel to the selected plane as it passes along the origin trajectory.
Trajpar

Variable section sweep features have a system parameter called ‘trajpar’ (trajectory parameter). Trajpar has a value that varies from 0 to 1 over the length of the origin trajectory. At the start point of the origin trajectory, trajpar is equal to zero (0). At the other end of the origin trajectory, trajpar is equal to one (1). At the halfway point along the trajectory, trajpar is equal to 0.5. This parameter can be used in sketcher relations to control sketch dimensions that vary along the trajectory.

In the example shown below, the width of the section is controlled by the X-vector trajectory. The height of the section is controlled by a relation using trajpar. At the start point, the sd7 dimension is 1.000, and varies to 4.000 at the end of the sweep, because of the relation and trajpar. The relation for this example is: \( sd7 = 1 + (\text{trajpar} \times 3) \)

Facts about Variable Section Sweeps

- The origin trajectory must consist of tangent entities only.
- The X-vector trajectory cannot cross the origin trajectory. However, either endpoint of the X-vector trajectory may touch the origin trajectory.
- All additional trajectories (which are optional) must start at the plane of the section being swept.
- The plane of the section being swept may intersect any trajectory only once at any given location along the sweep.
- If the plane of the section being swept cannot intersect all trajectories at the sweeps start point, a datum point on the origin trajectory may be used to define the sweep features start point.
**Boundary Blend**

A **Boundary Blend** is created by specifying curves that represent the outer boundary of the surface. Additional curves can be used to further define the shape of the surface. ‘Control points’ can be used to define the blending from one curve to the next, and the tangency of the surface at each boundary can be defined.

Pick **Insert, Boundary Blend** or pick the icon shown above. The **Boundary Blend** dashboard tool is shown below and the options are described on the next page.

- **Curves** panel lists the first and second direction curves
- **Constraints** panel lists the boundary conditions for the surface
- **Control Points** panel lists the control points here
- Use the right mouse button popup menu for shortcuts
- The top of the violin is an example of a blended surface
**Boundary Blend (continued)**

The **Boundary Blend** feature has many options as listed below.

<table>
<thead>
<tr>
<th><strong>First Direction Curves</strong></th>
<th>The curves or edges that define the boundary of the surface in the first direction.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Second Direction Curves</strong></td>
<td>Additional curves or edges that define the boundary of the surface in the second direction. Second direction curves are optional for some blended surfaces.</td>
</tr>
<tr>
<td><strong>Side Curve Influence</strong></td>
<td>For surfaces with ‘first direction curves’ only, the system changes the resulting surface by examining the curves that are adjacent to the selected boundary curves.</td>
</tr>
<tr>
<td><strong>Influencing Curves</strong></td>
<td>Additional curves that define an approximate boundary for the surface. This is not related to ‘side curve influence’.</td>
</tr>
<tr>
<td><strong>Control Points</strong></td>
<td>Used to control the internal tangent edges of the blended surface.</td>
</tr>
<tr>
<td><strong>Boundary Conditions</strong></td>
<td>One of the following four choices defines the surface’s topology at each of the selected boundary curve.</td>
</tr>
<tr>
<td><strong>Free</strong></td>
<td>No tangency condition is set.</td>
</tr>
<tr>
<td><strong>Tangent</strong></td>
<td>The surface is tangent to a selected reference entity.</td>
</tr>
<tr>
<td><strong>Normal</strong></td>
<td>The surface is perpendicular to a selected reference entity.</td>
</tr>
<tr>
<td><strong>Curvature</strong></td>
<td>The surface has continuous curvature (C2) to a selected reference entity.</td>
</tr>
</tbody>
</table>
**Boundary Blend - Example 1**

Consider the two extruded surfaces shown below. A blended surface will be created to connect the two surfaces along the edges shown in bold.

The blended surface is created using each tangent chain of the existing edge curves as a boundary. Without specifying any additional conditions, the blended surface is created as shown below. Notice how the center section of the surface has two sets of paired edges.

By defining the control points, the four (4) vertices on each chain of edges are matched to one another as shown below. The interior tangent lines of the surface are now correct, however the blended surface is not tangent to the original surfaces.
When the boundary conditions are set to ‘tangent’, the shape of the blended surface changes as shown below.

Curves can also be used to define the surface in the second direction as shown below.

Two tangent chains are used to define the boundary in the first direction. In addition, the three datum curves shown in bold above are used for the boundary in the second direction. The blended surface is shown below.
**Boundary Blend - Example 2**

Consider the datum curves shown below. These curves are used to create the blended surface also shown below. Each boundary condition is indicated by a circular icon. Move the cursor over the circular icon, then press and hold the right mouse button to access the popup menu. You can easily change the boundary conditions using this popup menu as shown below.

```
Curves for the first direction

Curves for the second direction

At each circular icon, use the popup menu to change the boundary condition

• Free
  Tangent
  Normal
  Curvature

Boundaries - Blended Surface
```
**Section to Surfaces Blend**

This type of feature creates a blended surface from a set of existing tangent surfaces to a sketched section. Consider the egg shaped surface and sketch shown below on the left. The tangent surfaces are shown meshed. Pick **Insert, Advanced, Blend Section to Surfaces, Surface**, then pick the surfaces, then sketch the section. The resulting blended surface is shown below on the right.

The **Section to Surface Blend** dialog box is shown.

- **Surfaces**: The existing tangent surfaces that the new surface will blend from.
- **Section**: The sketched section that the new surface will blend to.
- **Direction**: The direction of the blend defined by a datum plane.

![Section to Surfaces Blend](image)
**Surface to Surface Blend**

This type of surface feature creates a tangent surface between two existing surfaces. Consider the two hemispherical surfaces shown below.

Pick **Insert, Advanced, Blend Between Surfaces, Surface**, pick the two surfaces then pick **OK** in the dialog box. The resulting blended surface is shown.
**Exercise 3 - Advanced Surfaces**

Task 1: Create a variable section sweep.

- **Open** the part called ‘phone_cord.prt’
- Pick this sketch
- Press and hold the CTRL key and pick this sketch
- Pick the **Variable Section Sweep** icon
- Pick the **Sketch** icon in the dashboard tool
- Sketch and dimension a single line as shown below

```
<table>
<thead>
<tr>
<th>0.500</th>
</tr>
</thead>
<tbody>
<tr>
<td>30°</td>
</tr>
</tbody>
</table>
```

- Pick **Tools, Relations**
- Enter the following relation (use your sd# for the *angle* dimension)

  \[
  \text{sd\#} = \text{trajpar} \times 360 \times 100
  \]

- Pick **OK** in the **Relations** dialog box
- Pick the checkmark to complete the sketch
- Pick the checkmark in the dashboard tool to complete the feature
- **Hide** the **Sketch** and the **Offset** in the model tree
- Pick **View, Orientation, Standard Orientation**
• Pick **Insert, Sweep, Protrusion**
• Pick **Select Traj, One By One** in the small menus
• Pick the five edges as shown below

![Diagram of surface modeling](image)

• Pick **Done** in the small menu
• Pick **Okay** in the small menu
• Sketch a circle at the intersection of the centerlines, enter < 0.125 > for the diameter
• Pick the checkmark to complete the sketch
• Pick **OK** in the dialog box to complete the feature
• **Hide** the **Var Sect Sweep** in the model tree
• Pick **View, Visibility, Save Status**
• Pick **View, Orientation, Standard Orientation**
• The result is shown below
• **Save** the part and **Close** the window
Task 2: Create a boundary blend surface.

- **Open** the part called ‘contact.prt’
- Set the selection filter to **Geometry**
- Pick the first boundary as shown below (pick the tangent chain)
- Press and hold the CTRL key and pick the second boundary as shown below (also use a tangent chain)

- Pick **Insert, Boundary Blend** or pick the icon
- Pick the checkmark in the dashboard tool to complete the feature
- The result is shown below, notice the unmatched edges as shown below
Task 3: Redefine the feature to ‘map’ the control points.

- Pick the **Boundary Blend** feature then press and hold the right mouse button and select **Edit Definition** in the popup menu.
- Pick **Control Points** in the right mouse button popup menu.
- Select one of the red points on the *first* boundary, then select the corresponding point on the *second* boundary.
- Continue until all four pairs of points have been selected as shown below.

In the **Control Points** panel, there should be four (4) Sets listed.

- Click the checkmark in the dashboard tool to complete the feature.
- The result is shown, notice the edge pairs are properly matched in the blend area.
Task 4: Redefine the feature to set the boundary conditions.

- Pick the **Boundary Blend** feature then pick **Edit Definition** in the right mouse button popup menu.
- Move the cursor over the small circular icon on the geometry as shown below.
- Press and hold the right mouse button and select **Tangent** in the popup menu.
- Repeat for the second boundary.

![Diagram of boundary conditions]

Set the boundary condition to **Tangent**

- Pick the checkmark in the dashboard tool to complete the feature.
- The result is shown below.

![Result diagram]
Task 5: Create two datum points.

- Set the selection filter to *Geometry*
- Pick this edge approximately at the point shown
- Pick the **Insert Datum Point** icon
- Enter an offset value of < 0.333 > then pick **OK** to complete the feature
- Repeat this task, enter < 0.667 > for the offset value

Task 6: Create another boundary blend.

- Be sure the selection filter is set to *Geometry*
- Pick the first boundary as shown below (pick the tangent chain)
- Press and hold the CTRL key and pick the second boundary as shown below (also a tangent chain)
• Pick **Insert, Boundary Blend** or pick the icon 🍃
• Move the cursor over the small circular icon on the geometry as shown below
• Press and hold the right mouse button and select **Tangent** in the popup menu
• Repeat for the second boundary

- **T=0.000**
- **Set the boundary condition to Tangent**

• Pick **Control Points** in the right mouse button popup menu
• Select one of the red points on the *first* boundary, then select the corresponding point on the *second* boundary
• Continue until all six pairs of points have been selected (two of the vertices on the second boundary map to the two datum points on the first boundary)
• Pick the checkmark in the dashboard tool to complete the feature
• The result is shown below
• **Save** the part
Task 7: Set the side curve influence.

- Orient the model using the **Right** view
- Notice that the top edges do not meet tangent to the boundary in this direction

- Pick the **Boundary Blend** feature then pick **Edit Definition** in the popup menu
- In the **Constraints** panel of the dashboard tool, pick **Direction 1-First chain** then add the checkmark next to **Add side curve influence** as shown below
- Pick **Direction 1-Last chain**, then add the checkmark next to **Add side curve influence**
• Pick the checkmark in the dashboard tool to complete the feature
• Repeat this task for the other blended surface
• The final result is shown below
• **Save** the part and **Close** the window
Task 8: Create a boundary blend in the violin part.

- Open the part called ‘violin.prt’
- Set the selection filter to Datums
- Pick the three curves in the order shown below for the First Direction

![Diagram of violin showing curves 1, 2, and 3 in the first direction]

- Pick the Boundary Blend icon
- Press and hold the right mouse button and select Second Direction Curves in the popup menu
- Pick the three curves in the order shown below for the Second Direction (use Query Select to select the individual curves shown in bold)

![Diagram of violin showing curves 1, 2, and 3 in the second direction]
• Set each of the four boundary conditions to **Tangent** using the right mouse button popup menu as shown below

![Diagram showing boundary conditions](image)

• Pick the checkmark in the dashboard tool to complete the feature

• The result is shown below

![Model result](image)

• **Save** the part and **Close** the window
Task 9: Create a new part and a variable section sweep.

- Pick **File, New**, enter < candle_glass > for the name, then pick **OK**
- Pick the TOP datum plane
- Pick the **Sketch** icon
- Click the middle mouse button to accept the default orientation
- Sketch a circle aligned with the two references
- Enter < 1.000 > for the diameter of the circle
- Pick the checkmark to complete the sketch
- Pick **View, Orientation, Standard Orientation**
- Pick the sketch you just created
- Pick the **Variable Section Sweep** icon
- Pick the **Sketch** icon in the dashboard tool
- Sketch and dimension a single line as shown below

```
0.100

0.200
```

- Pick **Tools, Relations**
- Enter the following relation (use your sd# for the **0.100** dimension)

\[ sd# = \sin ( \text{trajpar} \times 360 \times 6 ) / 20 \]

- Pick **OK** in the **Relations** dialog box
- Pick the checkmark to complete the sketch
• Pick the checkmark in the dashboard tool to complete the feature
• **Hide** the Sketch in the model tree

**Task 10: Create construction curves and surfaces.**

• Pick **View, Orientation, Standard Orientation**
• Pick the TOP datum plane
• Pick the **Insert Datum Plane** icon
• Enter `< -1.250 >` for the offset value
• Pick **OK** in the dialog box to complete the feature
• Pick the **Sketch** icon
• Click the middle mouse button to accept the default orientation
• Sketch a circle aligned with the two references
• Enter `< 0.750 >` for the diameter of the circle
• Pick the checkmark to complete the sketch
• Pick **View, Orientation, Standard Orientation**
• Pick the sketch you just created
• Pick the **Variable Section Sweep** icon
• Pick the **Sketch** icon in the dashboard tool
• Sketch and dimension a single line as shown below
• Pick **Tools, Relations**

• Enter the following relation (use your sd# for the **0.100** dimension)

\[ \text{sd#} = 0.030 + \left( \sin \left( \text{trajpar} \times 360 \times 6 \right) / 50 \right) \]

• Pick **OK** in the **Relations** dialog box

• Pick the checkmark to complete the sketch

• Pick the checkmark in the dashboard tool to complete the feature

• Pick **View, Orientation, Standard Orientation**

• **Hide** the **Sketch** in the model tree

• **Save** the part

---

**Task 11: Create a boundary blend surface.**

• Set the selection filter to **Geometry**

• Pick two tangent chains as shown in bold below

• Pick the **Boundary Blend** icon
• Pick the checkmark in the dashboard tool to complete the feature
• **Hide** both **Var Sect Sweep** features in the model tree
• Pick **View, Visibility, Save Status**
• Pick **View, Orientation, Standard Orientation**
• The result is shown below
• **Save** the part and **Close** the window
Task 12: Create a boundary blend surface.

- Open the part called ‘container.prt’
- Hide the extruded surface in the model tree
- Hide the flat surface in the model tree
- Pick the two curves as shown below for the **First Direction**

```
1
2
```

- Pick the **Boundary Blend** icon
- Press and hold the right mouse button and select **Second Direction Curves** in the popup menu
- Pick the three curves as shown below for the **Second Direction**

```
1
2
3
```

- Press and hold the right mouse button and select **Control Points** in the popup menu
- Select one of the red points on the first boundary, then select the corresponding point on the second boundary
• Continue until all six pairs of points have been selected as shown below

• Pick the checkmark in the dashboard tool to complete the surface
• Pick the Mirror icon
• Pick the RIGHT datum plane to mirror about
• Pick the checkmark in the dashboard tool to complete the mirror command
• The result is shown below
• Save the part and Close the window
Task 13: Create four boundary blend surfaces.

- **Open** the part called ‘mouse.prt’ then orient the part as shown below
- Set the selection filter to *Geometry*
- Pick the two edges and two curves as shown below

![](image)

- Pick the **Boundary Blend** icon
- Set the top boundary condition to **Tangent** using the right mouse button popup menu as shown below

![](image)

- Pick the checkmark in the dashboard tool to complete the surface
- Pick the two curves as shown below for the **First Direction**
• Pick the **Boundary Blend** icon 📊

• Press and hold the right mouse button and select **Second Direction Curves** in the popup menu

• Pick the two edges as shown below for the **Second Direction** (one is a tangent chain)

• Pick the checkmark in the dashboard tool to complete the surface

• Create a similar blended surface on the opposite side of the part

• Orient the part as shown below

• Pick the two edges and two curves as shown below

• Pick the **Boundary Blend** icon 📊

• Set the top boundary condition to **Tangent** using the right mouse button popup menu

• Pick the checkmark in the dashboard tool to complete the surface

• The result is shown below

• **Save** the part and **Close** the window
Task 14: Create four boundary blend surfaces.

- **Open** the part called ‘speaker_housing.prt’
- **Hide** the extruded surface
- Pick the four curves as shown below

![Image of four curves]

- Pick the **Boundary Blend** icon
- Pick the checkmark in the dashboard tool to complete the surface
- Pick the four curves as shown below

![Image of four curves]

- Pick the **Boundary Blend** icon
- Pick the checkmark in the dashboard tool to complete the surface
• Repeat this task to create a total of five (5) boundary blends
• The bottom surface (hidden) will be merged in a later exercise
• The result is shown below
• Save the part and Close the window

Task 15: Create a section to surface blend.

• Open the part called ‘egg_package.prt’
• Pick Insert, Advanced, Blend Section to Surfaces, Surface
• Pick the three meshed surfaces shown below
• Pick **OK** in the Select dialog box
• Pick the TOP datum plane for the sketch plane
• Pick **Okay, Default** in the small menus
• Sketch and dimension the four tangent arcs as shown below

- Pick the checkmark to complete the sketch
- Pick **OK** in the dialog box to complete the surface
- Pick View, Orientation, Standard Orientation
- The result is shown below
- **Save** the part and **Close** the window
Task 16: Create boundary blend surfaces.

- **Open** the part called ‘golf_driver.prt’
- Set the selection filter to **Geometry**
- Use **Query Select** to pick this curve segment

- Press and hold the CTRL key and use **Query Select** to pick this curve segment
- Pick the **Boundary Blend** icon
- Press and hold the right mouse button and select **Second Direction Curves** in the popup menu

- Pick the two curves as shown here for the **Second Direction**
- Pick the checkmark in the dashboard tool to complete the surface
- The blended surface is shown below
• Be sure the selection filter is set to Geometry

• Use Query Select to pick this curve segment
• Press and hold CTRL and pick this curve
• Pick the Boundary Blend icon
• Press and hold the right mouse button and select Second Direction Curves in the popup menu
• Pick the two curves as shown here for the Second Direction
• Pick the checkmark in the dashboard tool to complete the surface
• The blended surface is shown below
• Save the part and Close the window