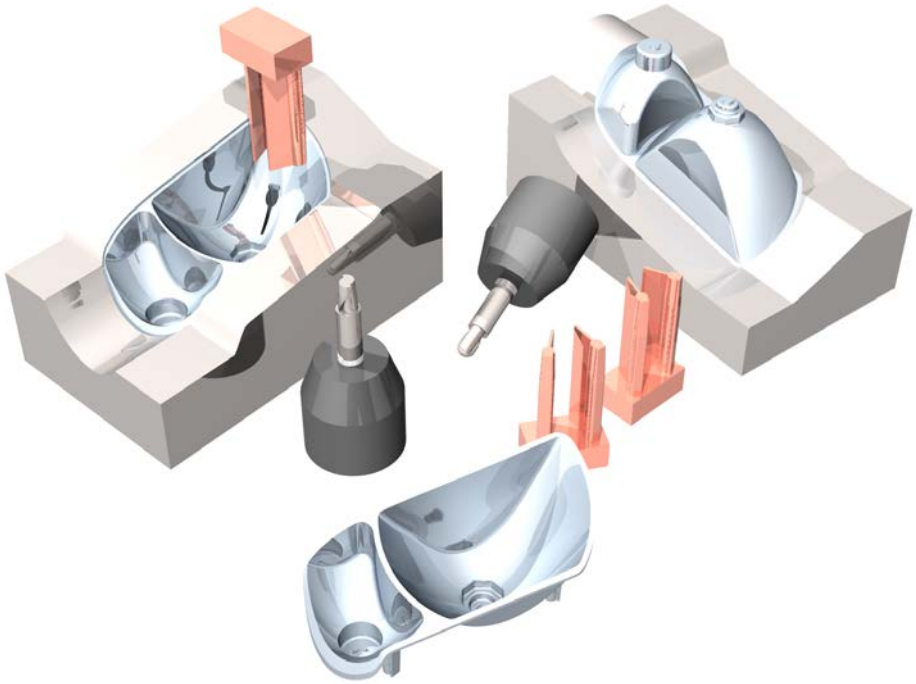

PowerMILL Modelling Training Course

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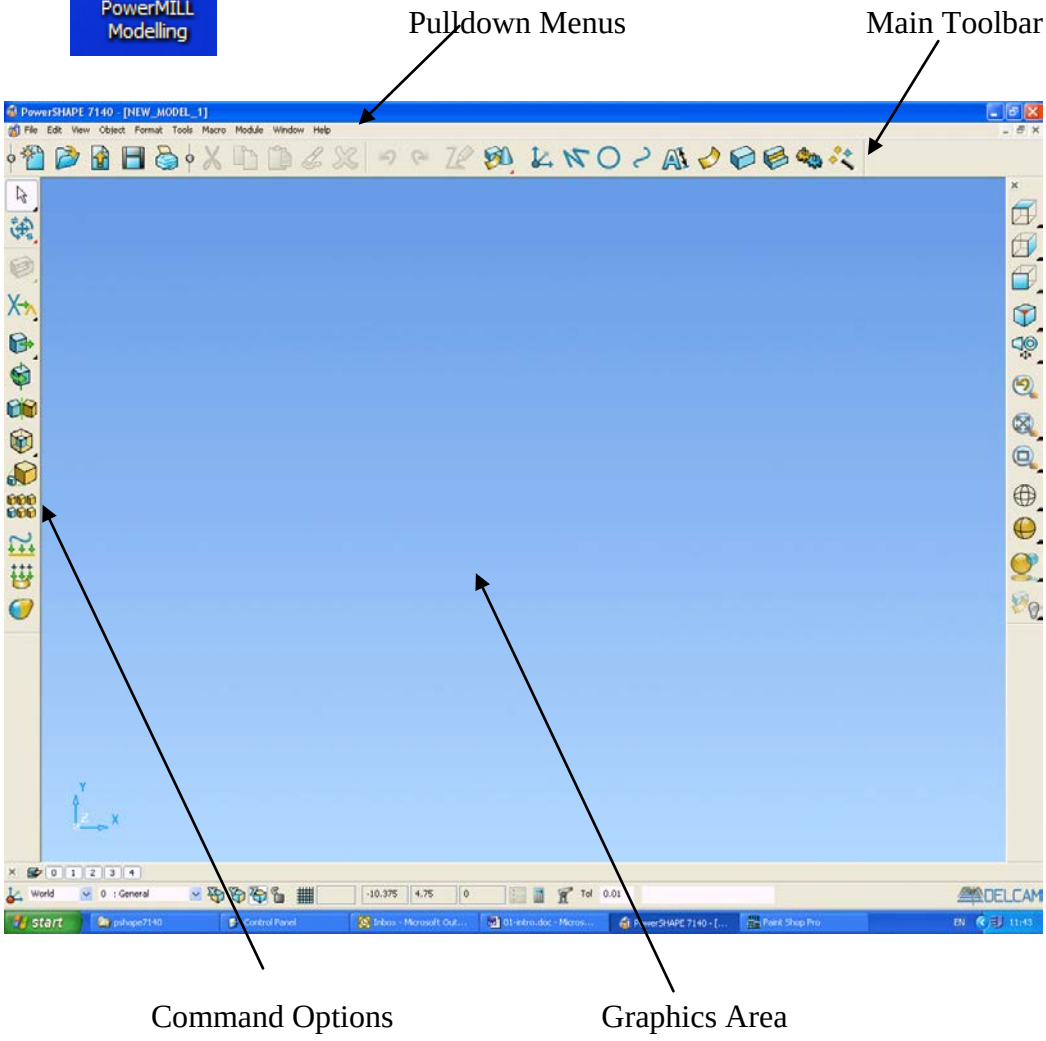
1. Introduction

PowerMILL Modelling Introduction.

PowerMILL Modelling is an add-on to PowerMILL that provides comprehensive surface modelling functions from within a PowerMILL session. For simplicity, all of the training examples contained in this document will use a standalone version of PowerMILL Modelling.

- To open ***PowerMILL Modelling***, **double click** on the desktop icon.

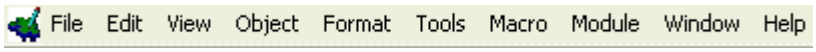
Once loaded, the screen looks as shown.



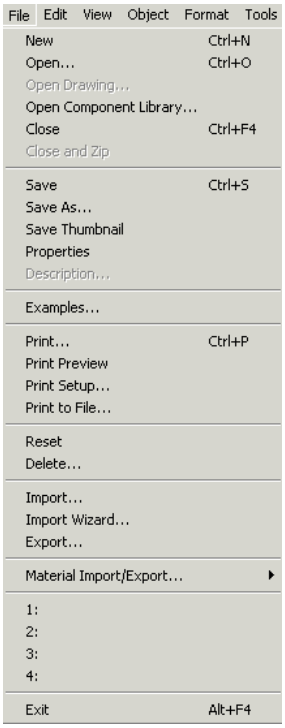
PowerMILL Modelling automatically starts a New Model for the user to work in. The Model name is displayed at the top left hand corner. Note that a New Model is not stored externally to disc.

The model can be **Saved** permanently with a more appropriate name and stored to an external directory. One or more previously stored **models** can be opened within the same **PowerMILL Modelling** session.

At the top of the screen there are a series of pull down menus.



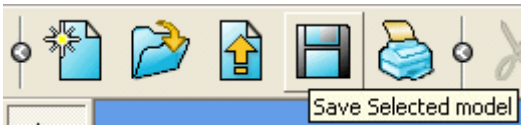
- Select the **File** menu, using the **Left** mouse button.



This menu contains a comprehensive list of operations available.

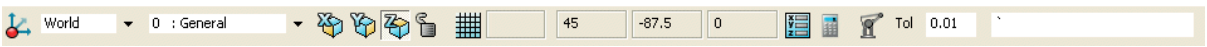
Beneath the pull down menus are the **Main Toolbar** icons which when clicked either open up a form alter the choice of command icons located to the left of the graphics area.

If the mouse is held over an icon for a few seconds, a box containing a description of the command (tooltips) will appear.



To the bottom left of the graphics area is the **Levels** menu to which entities can be assigned for long term, group selections.

At the bottom of the screen is the **Workplane Selector**, **Principal Plane** selector, the grid definition, the cursor position, the tolerance and the **XYZ** position input area.



To the top right of the **Main** toolbar are several icons providing access to **Workplane**, **Line, Arc**, **Curve**, **Annotation**, **Surface**, **Solid**, **Feature**, **Assembly**, and **Wizard** options.

When one of the above icons is selected a context sensitive menu appears in the toolbar to the left of the graphics area. The shared toolbar will contain all of the main options for creating the chosen entity.

- **Select** the menu for **line creation**.

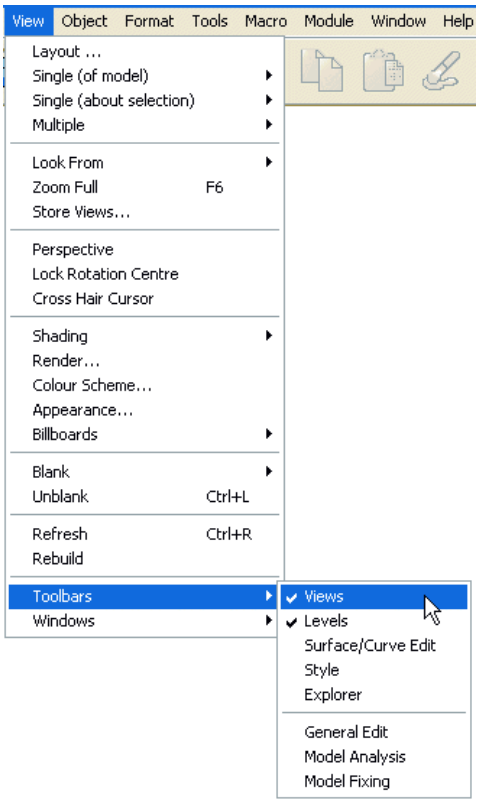
The top 2 icons are fixed and comprise **Selection** and **Model - Editing/Fixing/Analysis**.

The remaining icons from 3 downwards change depending on the option selected from the **Main** toolbar.

This part of the toolbar is currently shown with the **line** creation options.

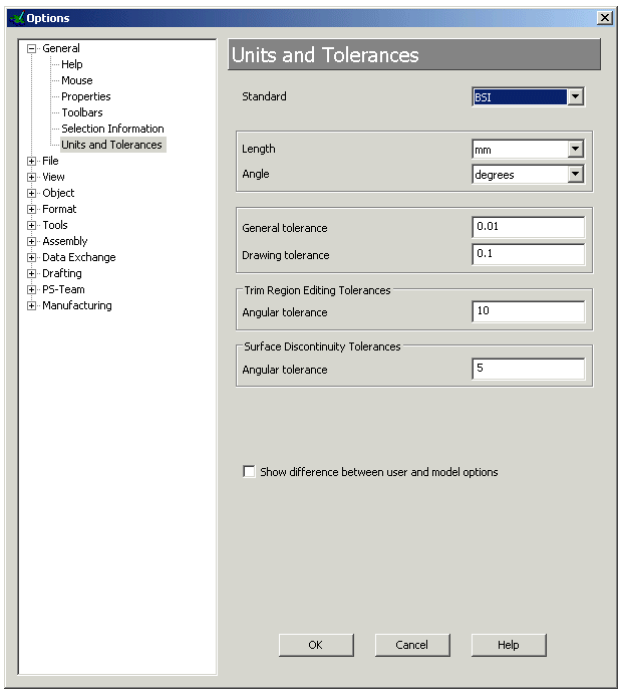
Toolbars

All of the toolbars, can also be switched on and off from the **View** pull down menu and selecting **Toolbars** ➔.



PowerMILL Modelling Options

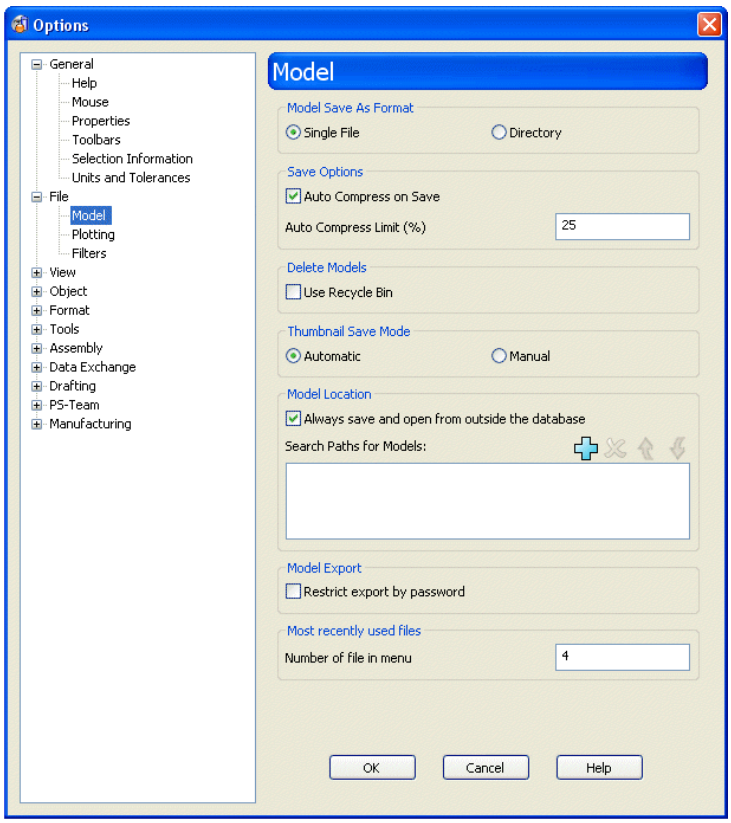
The **Tools ➔Options** page allows the user to configure ***PowerMILL Modelling*** to be different from the factory, default settings.



The options are stored within several main categories, accessible by clicking on the adjacent plus symbol.

It is possible to make changes to the factory default options and store them as the new default settings to be active with subsequent ***PowerMILL Modelling*** sessions.

- In **File – Model** (if not already set) tick the box ***Always save and open from outside the database***.

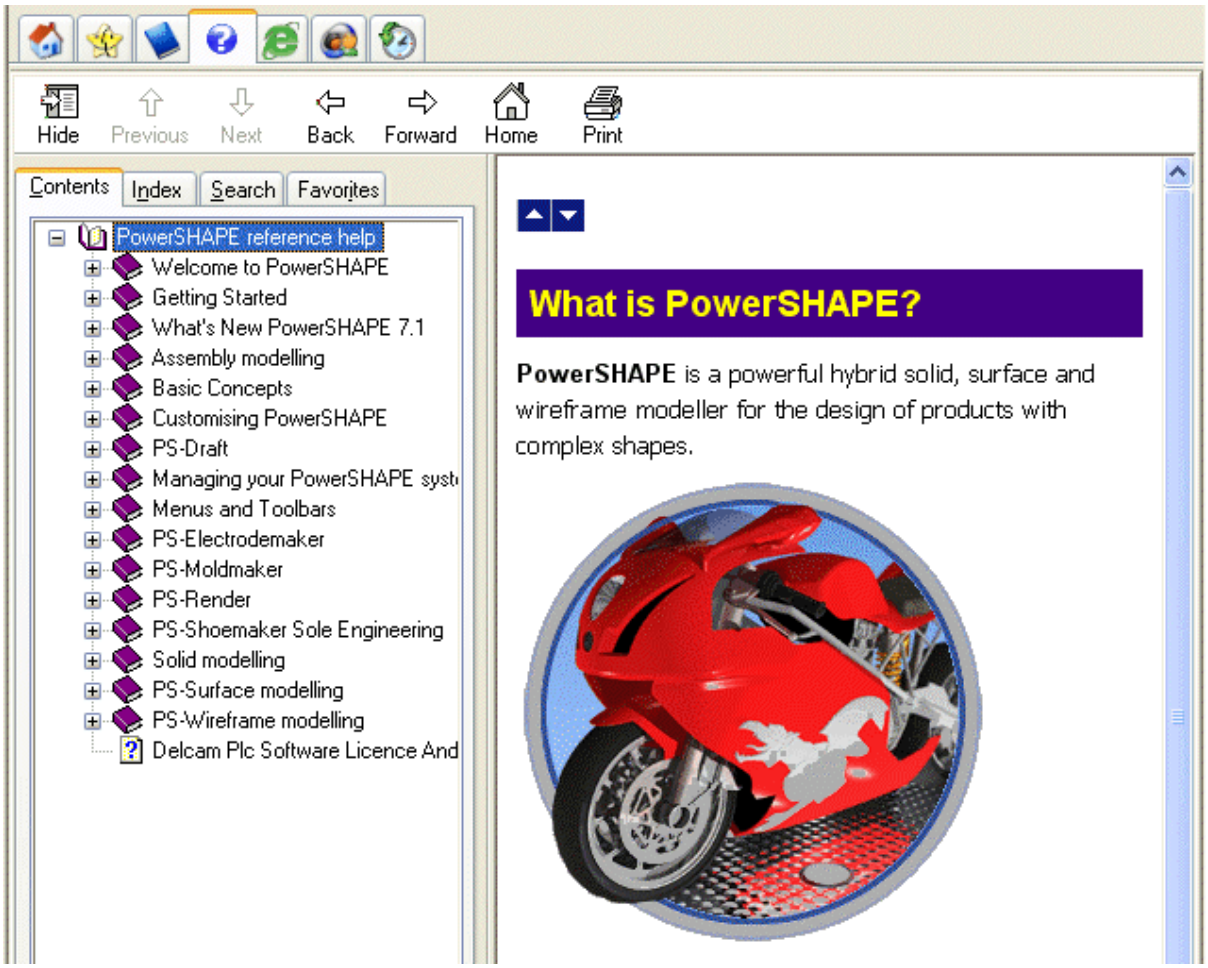


- Select **Cancel**.

Help Contents and Index

PowerMILL Modelling has an extensive Help index that can be accessed by either selecting Help from the top menu or by simply pressing **F1** on the keyboard.

- Press **F1** on the keyboard followed by **Getting Started** – **What is PowerMILL Modelling?** in the display window.



Topics are listed down the left hand window and the specific help for a selected item is displayed in the right hand window.

The Hide button can be pressed to hide the topics. The button then turns to say SHOW which if pressed the topic list re-appears.

If help is no longer required the window can be closed by selecting the '**x**' located to the top right of the browser area.

- **Close** the help window using the **X** button at the top right hand corner.

Mouse buttons

Each of the three mouse buttons performs a different operation in PowerMILL Modelling. By using the ALT, Ctrl or Shift key, these operations can be extended as the following details explain.

Left Mouse button 1: Picking and selecting

This button is used for selecting items off the main pull down menus, inputting and selecting parts of the model.

Middle Mouse button or wheel: Dynamics

Zooming: - Hold down the CTRL key and button/wheel and move the mouse up and down to zoom in and out of the view. Hold down the CTRL, Shift Key and button/wheel to select a framed area to zoom into.
Panning: - Hold down the SHIFT key with the button/wheel moving the mouse, to move the view across the component.
Rotating: Hold down button/wheel and move the mouse. A tracker ball appears at the centre of rotation, as does the view orientation axis in the bottom left corner of the screen. If view spinning is on the view will spin around until the user executes a further.

The wheel can be used to scroll text, if your mouse has a wheel.

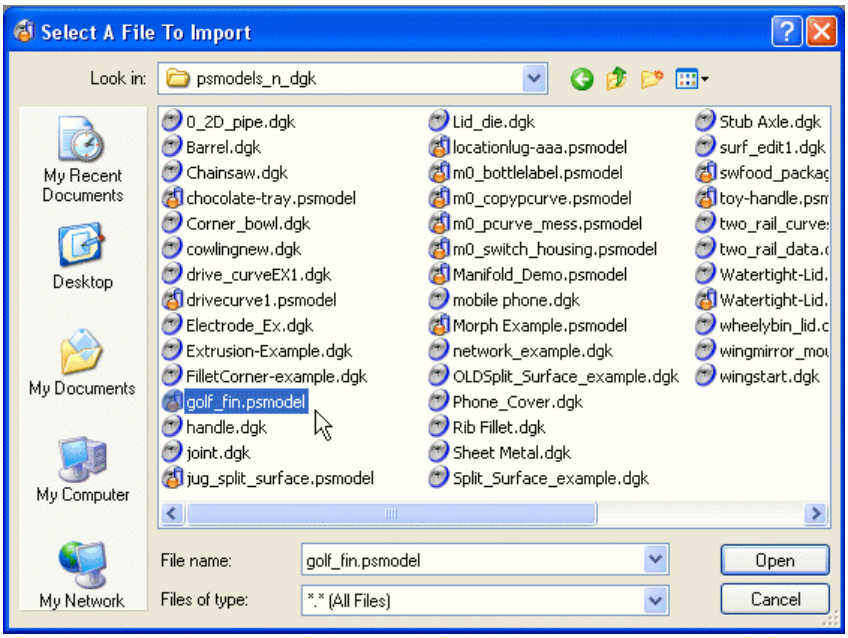
Mouse button 3: Special Menus

When this button is held down it brings up a new menu dependant on whatever the mouse is over. If nothing is selected, the View menu appears. If for example a line is selected, then the Line menu appears.

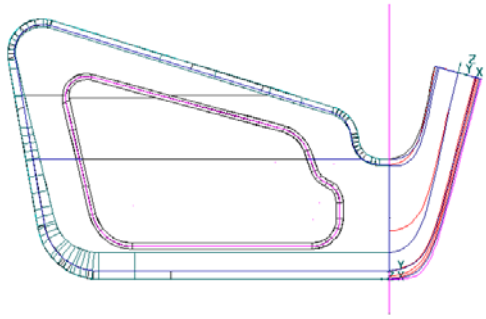
Exercise 1: Dynamic mouse controls.

In this exercise the user will **Import** an existing stored model and change the views using the dynamic mouse options.

- From the main menu select **File – Import** to open the following form:-



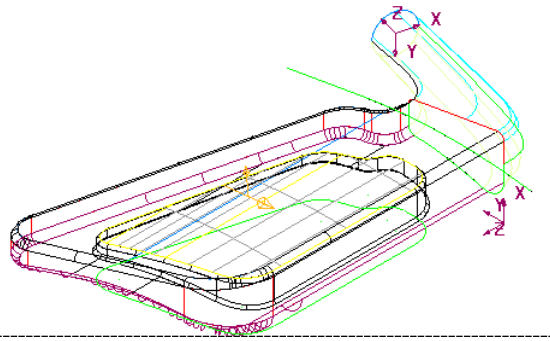
- **Import** the model:- **…\PowerMILL Modelling_Data\psmodels_n_dgk\golf-fin.dgk**



When a **model** is loaded into a new ***PowerMILL Modelling*** session the default **view** is down the ***Z-axis***.

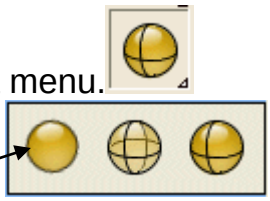
The view toolbar, on the right hand side of the PowerMILL Modelling window, can be broken down into 3 main areas, **standard views**, **dynamics** and **shading**.

- **Select** the view **Iso 1**.

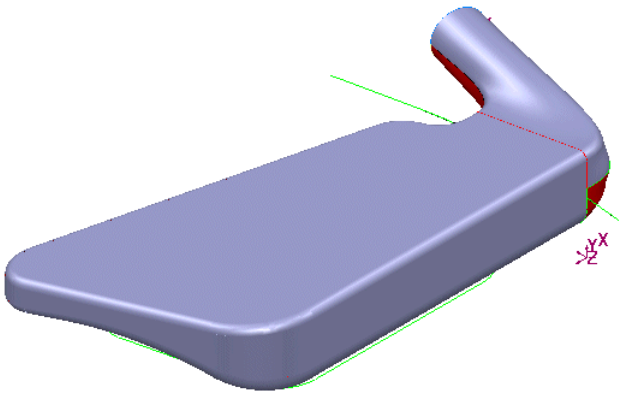


The model is now displayed using the first of 4 **isometric** views. **Surface** or **Solid** entities of the model can be displayed as **shaded** if required.

- From the views toolbar select **Shaded view** pull out menu.

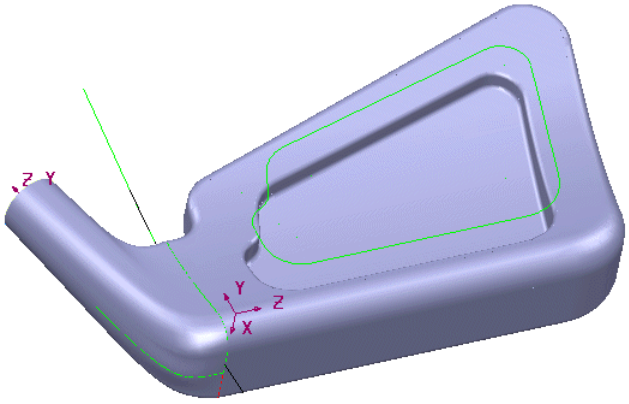


- From the available options pick **Shaded View**.

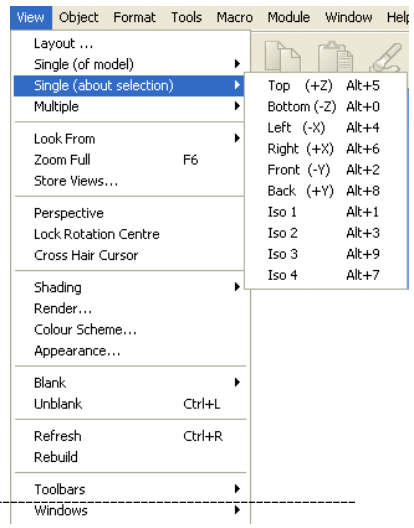


The surfaces have been shaded to show the full extent of the surface area. The wireframe from which it is constructed can also shown if required. The model can be rotated dynamically so that the user can view the underside detail.

- **Hold down** the **middle mouse button** and **move** the **mouse** to rotate the view to display the underside.
- **Hold down Shift** and **Middle mouse button** and move the mouse to position the view centrally over the model.



The underside can now be seen clearly. There are many different options for viewing the model that you can select. There are also a variety of keyboard shortcuts that you can use.

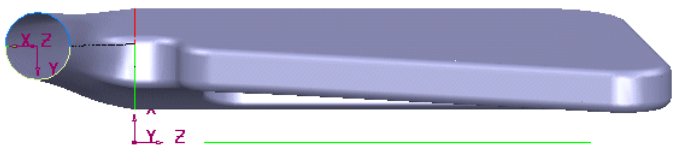


- Select **Views ➔ Single [about selection]**.

The keyboard shortcut for the views are listed, i.e. Alt + 1 for Iso 1. By switching Num Lock on the keyboard, the number pad can be used with the Alt key to change the views.

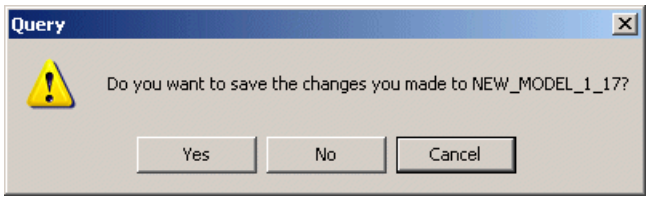
There is also an enhanced shading option that displays the model in a Perspective view with the lines running to a vanishing point as if on the horizon.

- **Select Back [+Y].**



Another view is displayed. The PowerMILL Modelling model needs to be closed. In this case it does not need to be saved, as the model has not been altered.

- Select **File ➔ Close**.

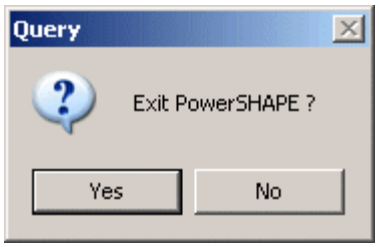


A message box appears asking if it is required to save the changes. In this case no changes have been made to the model.

- Select **No**.

The current model is now closed.

- Select **File ➔ Exit**.



A message box appears asking if it is okay to exit PowerMILL Modelling.

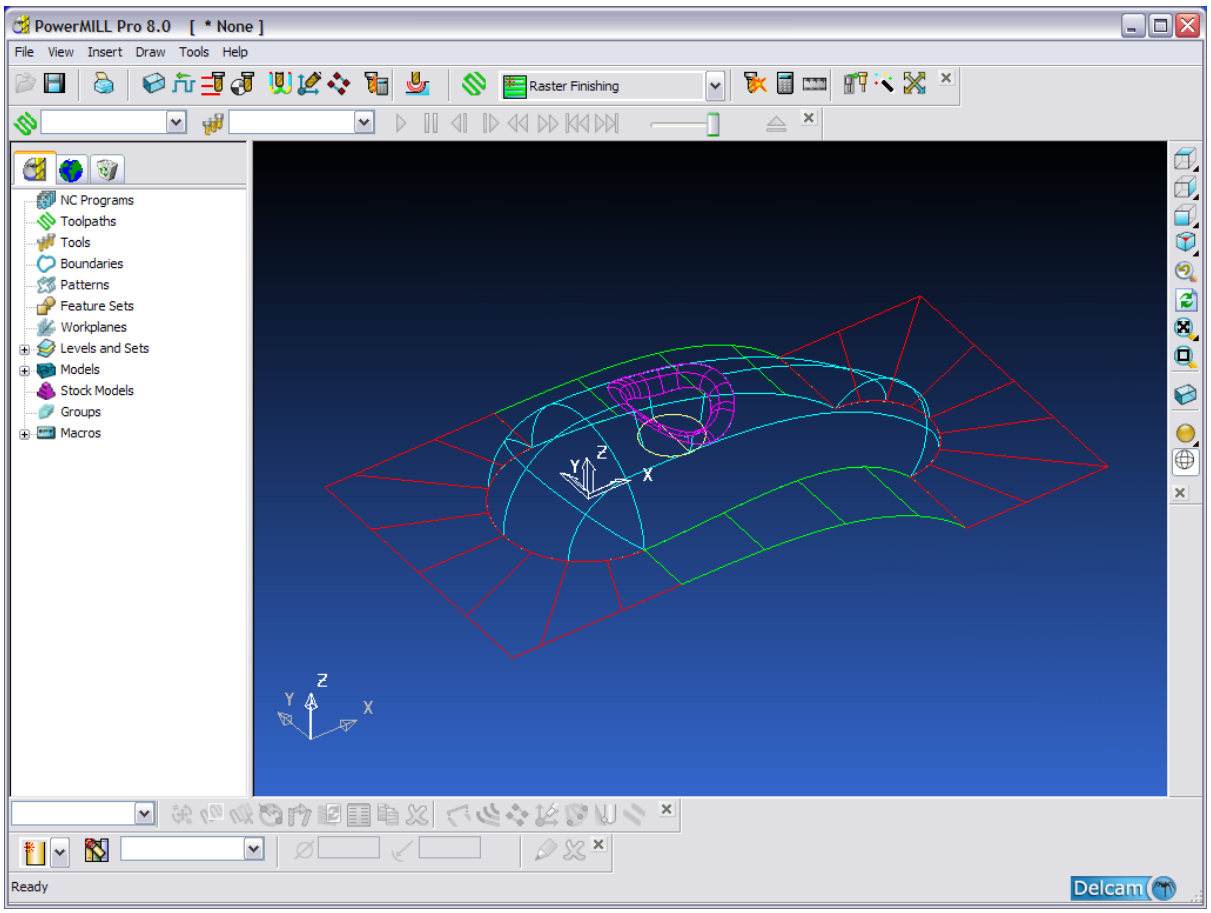
- Select **Yes**.

PowerMILL Modelling has been closed.

Running PowerMILL Modelling from PowerMILL

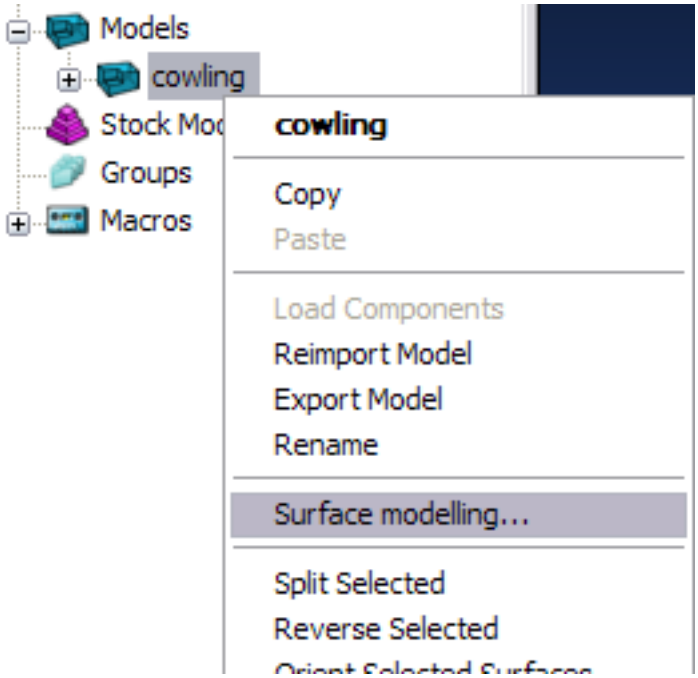
To run PowerMILL Modelling from within a PowerMILL session, you must first have an open ***Project***.

Start PowerMILL, by clicking on the desktop icon.
Load the file ‘Cowling.dgk’ from the PowerMILL examples folder.

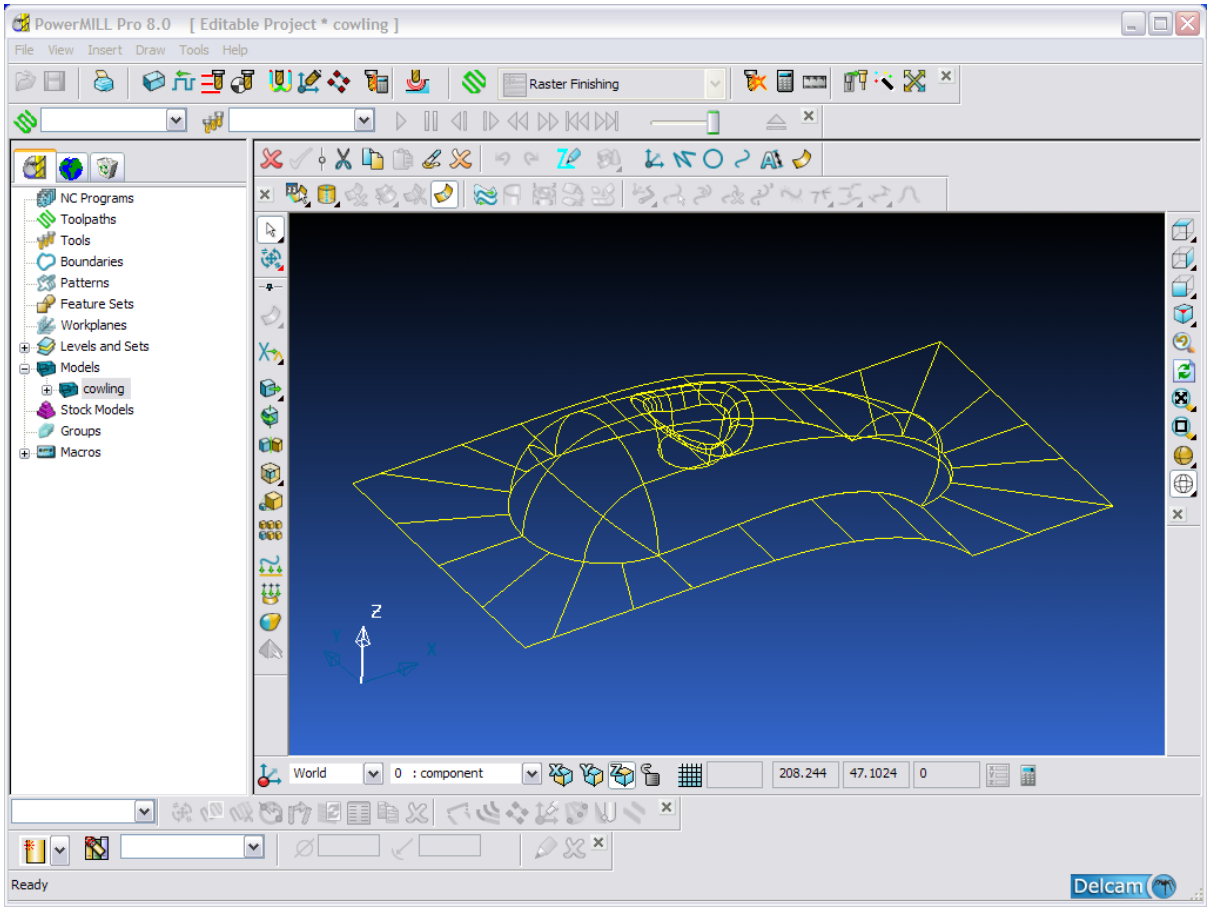


Save the ***Project*** into your home folder **D:\users\training\coursework\powermill_projects.**
Call the Project ‘Cowling’.

Click on *Models* in the tree browser, to open the branch, and reveal the Model ‘*cowling’*.
Right-click on ‘cowling’ and select ‘Surface Modelling’ from the list.

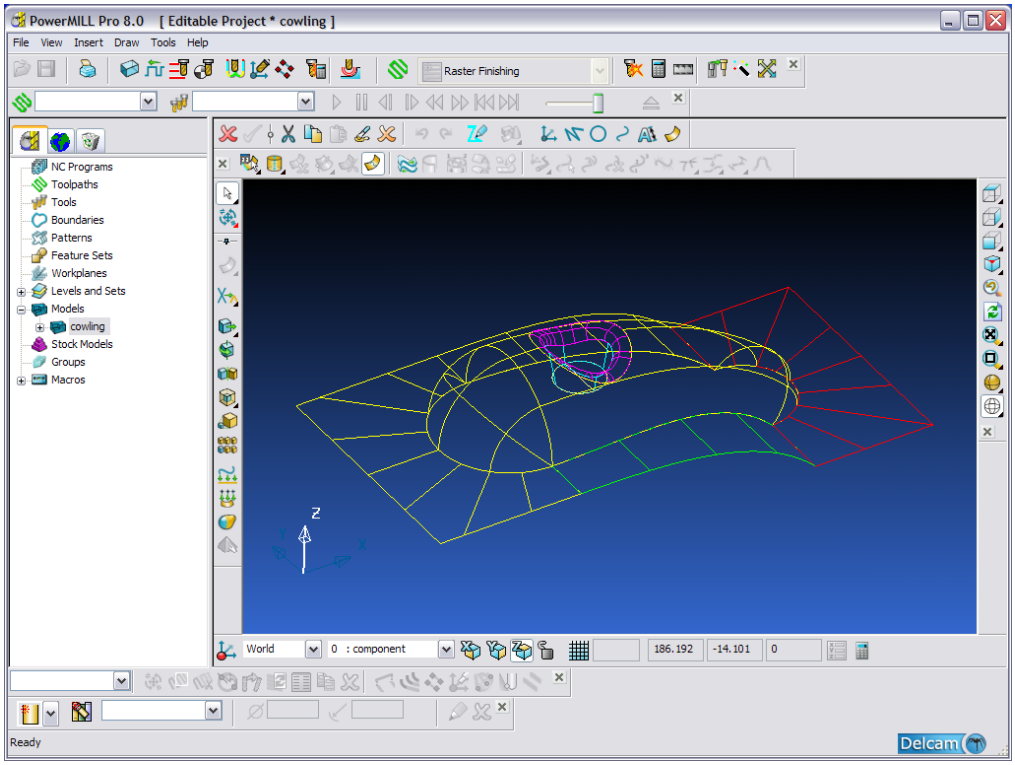


The PowerMILL Modelling window will open, ‘docked’ inside PowerMILL. The model will also be transferred. Note that this may take a while. If PowerMILL Modelling is started in advance, the delay is significantly shorter.



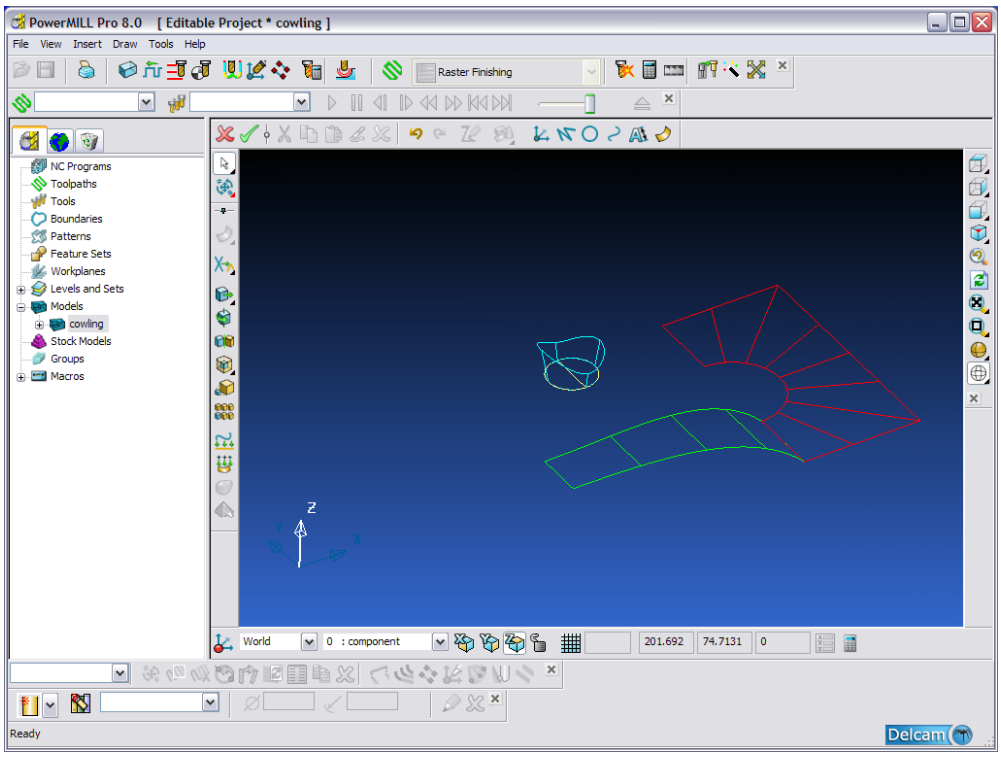
PowerMILL Modelling, complete with its own toolbars, docked inside PowerMILL.

Using the Left Mouse button, select any of the surfaces.

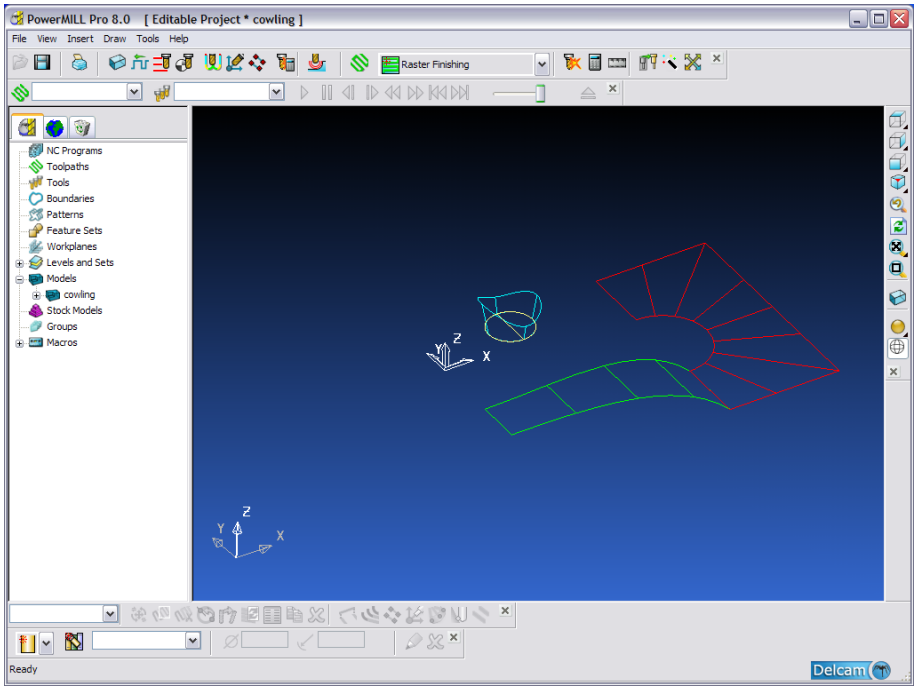


Press the ‘Delete’ key on your keyboard.

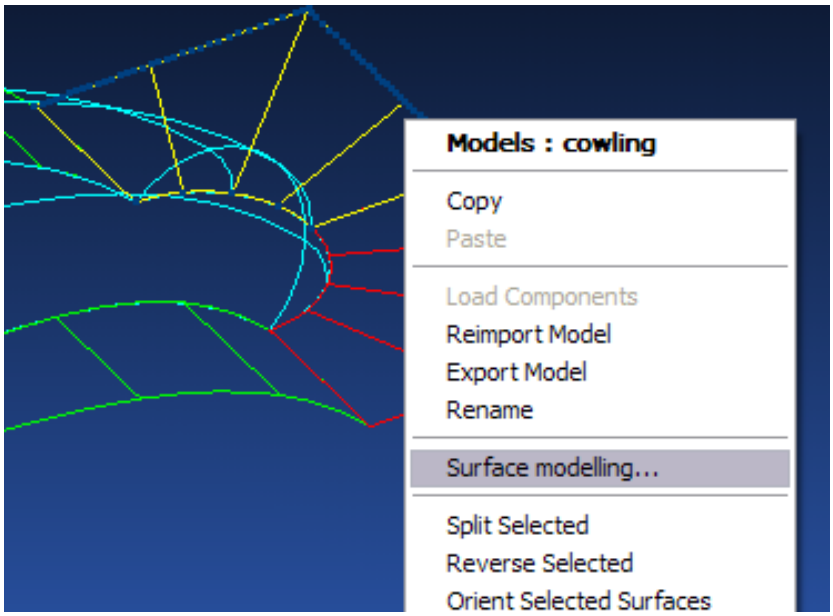
This will (fairly obviously) delete the selected surfaces.

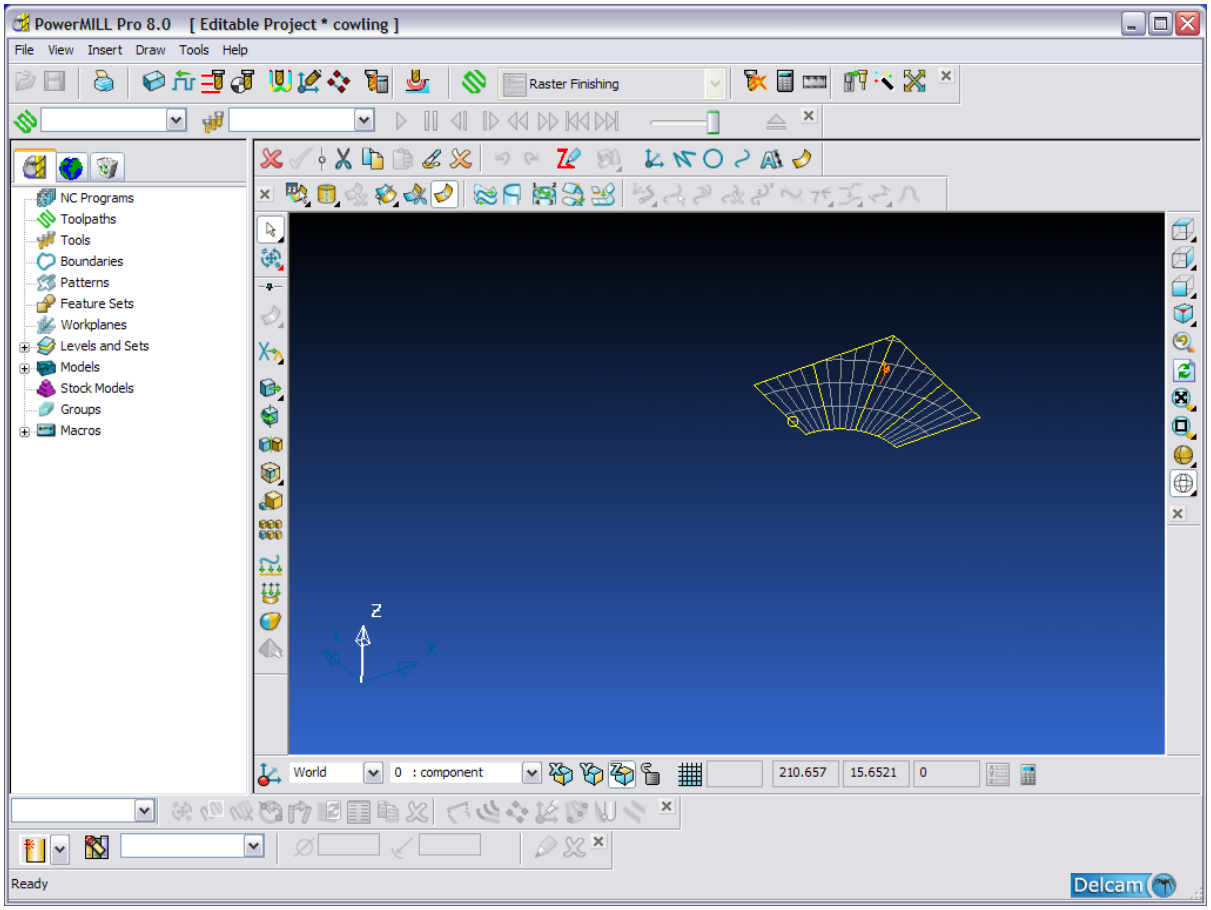


To send the changes you have made back to PowerMILL, click the green ‘tick’ icon in the top left corner of the PowerMILL Modelling frame.



Sometimes you do not wish to send the entire model to PowerMILL Modelling. In that case, simply select the surfaces you wish to send, and choose “Surface modelling…” from the right-click menu in the main window.





Quit PowerMILL Modelling by clicking the red cross icon at the top left corner of the PowerMILL Modelling window.

Exit from PowerMILL.

IMPORTANT NOTE: Some functions described in this course are only available when the program is run standalone. These function are highlighted thus-

This function only available Standalone

Some functions described in this course rely on you having full licences for PowerSHAPE. These function are highlighted thus-

This function only available in full version

2. Generating Wireframe

Introduction

PowerMILL Modelling can generate **Points**, **Lines**, **Arcs**, and **Curves** both in 2D and 3D space. These are collectively known as **wireframes** and have several uses, such as being the basic framework for several types of **Surfaces** and **Solids**, and as the drawing entities in **PS-Draft** or **PS-Estimator**. **Wireframes** can be **Exported** for use in other software products such as **PowerMILL**.

Wireframe Line and Arc Options

The **wireframe Line** and **Arc** options are accessed from the **main** toolbar.

Single Line

Continuous lines

Rectangle

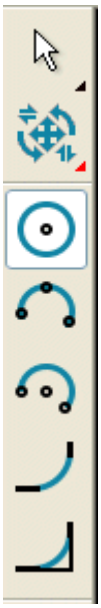
Polygon

3D box around selected items

Shortest line between 2 objects

Trimmed Chamfer

Untrimmed Chamfer



Full Circle

Arc Through Three pts.

Swept Arc About Centre

Trimmed Fillet

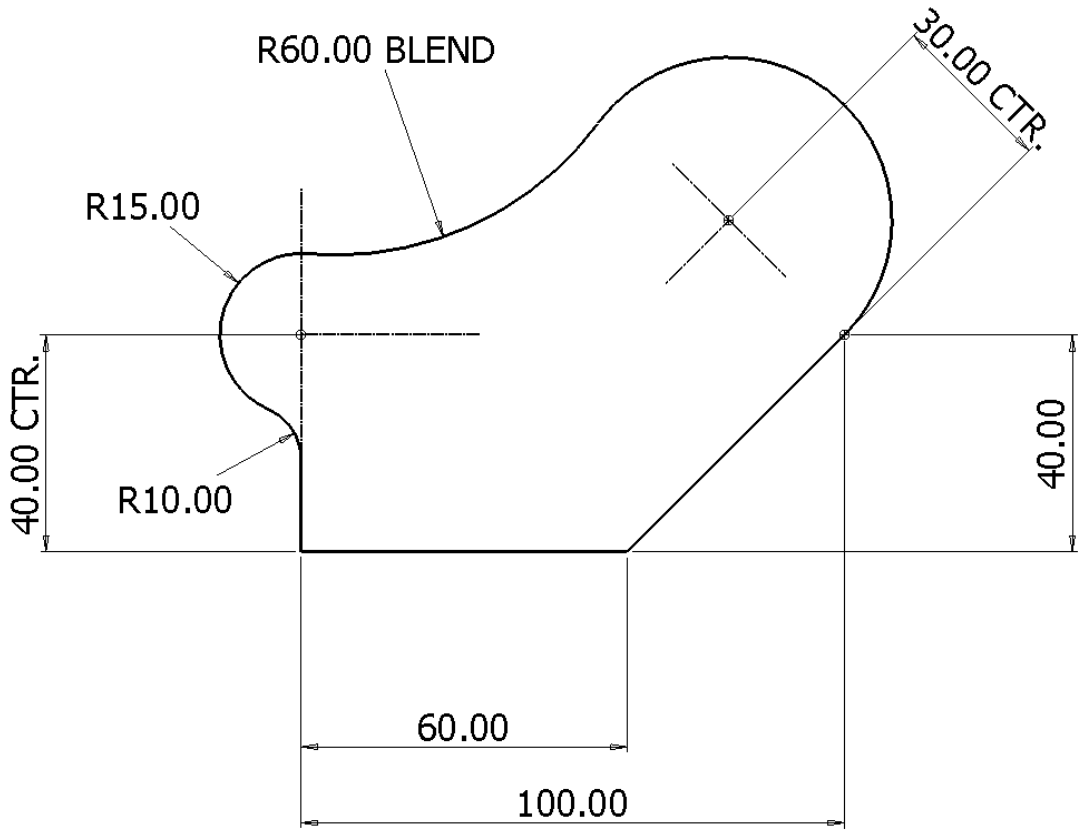
Untrimmed Fillet

- From the ***top pulldown*** menus select **File – New**, or alternatively click on the **Open New Model** icon from the **main** toolbar.

A ***new model*** will be opened in the current **PowerMILL Modelling** session.

Wireframe Lines and Arcs Exercise

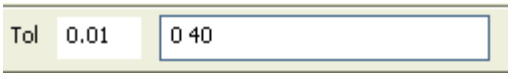
The following tutorial will show the basic operation of the **Wireframe** modeller by recreating the 2D profile shown below.



Line Creation

A **single line** will be generated from **0** to **y40** to coincide with the **R 15 arc *centre***.

- **From** the **Line menu** select **Single Lines**.
- Enter the start co-ordinate of **0** and press **Return**.
- **Input** the values **0 40** in the **Command input box** (lower right of graphics area) and press **Return**.



The next part will be generated using **continuous lines**.

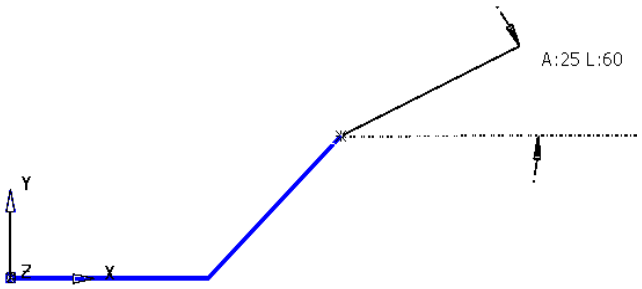
- From the **Line menu**, select **Continuous Lines** option.
- **Snap** to the **start** of the **first line** (or enter **0** in the ***command input*** box).
- **Input** the value **60** in the **Command input** box followed by **Return**.
- **Input** the value **40 40** in the **Command input** box followed by **Return**.

The Intelligent Cursor

The **Intelligent Cursor** displays preview information and locks onto ***key points*** and ***major directional*** axes during dynamic **wireframe** creation.
With the **continuous line** mode still active, a construction **line** to locate the **R30** ***centre*** will be dragged ***dynamically*** while being monitored by the **Intelligent Cursor**.

Note:- If the **Intelligent Cursor** functionality does not appear, right click within the graphics area to open the local ***view menu*** and check that the option **Intelligent Cursor** is **ticked**.

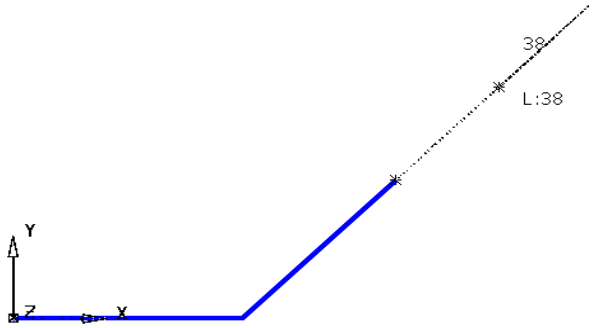
- By moving the mouse, dynamically **drag** the ***end*** of a new **line** away from the current position (as shown below) and observe the effect of the **Intelligent cursor** (do not click the left mouse key yet).



In the diagram the end of new line has currently been dragged to a relative, preview position at an angle of **25 degrees** with a length of **60**.

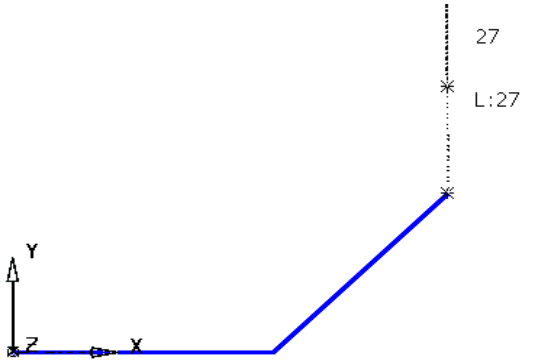
Note:- The **X** direction is **0 degrees** and the **Y** direction is **90 degrees** anticlockwise.

- By moving the mouse further, dynamically drag the end of a new **line** to a position ***tangential*** to the previous **line** and observe the effect of the **Intelligent cursor** (do not click the left mouse key yet).



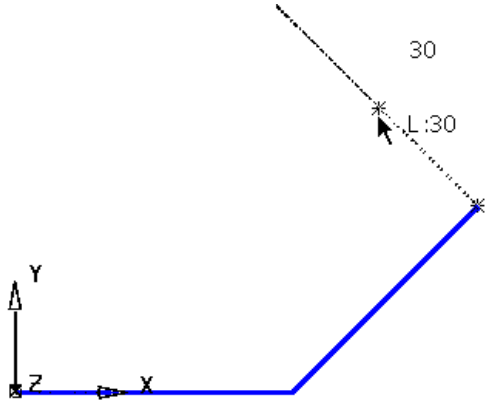
In the diagram the end of new **line** has currently, ***locked*** onto the ***tangency*** of the previous line and has been dynamically dragged away with a preview length of **38**.

- By moving the mouse further, dynamically drag the end of a new **line** position to a position along the **Y** direction and observe the effect of the **Intelligent cursor** (do not click the left mouse key yet).



In the diagram the end of new **line** has ***locked*** onto the **Y** ***direction*** and has been dynamically dragged away with a preview length of **27**.

By moving the mouse further, dynamically drag the end of a new **line** to a distance of **30** along the ***normal*** (**90** degrees) direction and this time ***click*** the left mouse key at accept the **line**.



The intelligent cursor has locked onto the **normal** (**90 degrees**) direction from the end of last **line**. The cursor has been dragged along this normal until a length of **30** is displayed.
The ***end position*** is accepted by applying a ***left mouse click***.

- Press **Escape** to exit **line** creation.

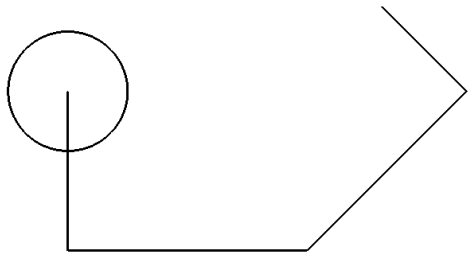
Arc Creation

The remainder of the **wireframe** is to be created using various **arc** options.

- **From** the **Arc Menu** **select Full Arc** .
- Input the value **r 15** in the **Command input box** and press **Return**.

(This input will redefine the ***default radius***).

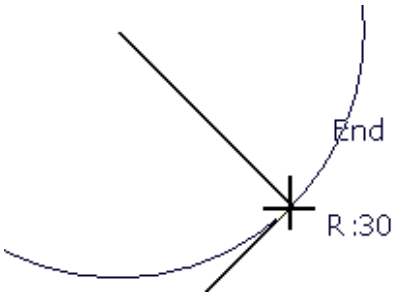
- **Move** the **cursor** over the open end of the vertical line until the text **End** is displayed then **click** the **left mouse key** to snap the circle centre position.
- Press **Select**.



If it is required to modify the **Circle**, quickly double click it with the left mouse key and the relevant **Arc** editor **Form** will appear.

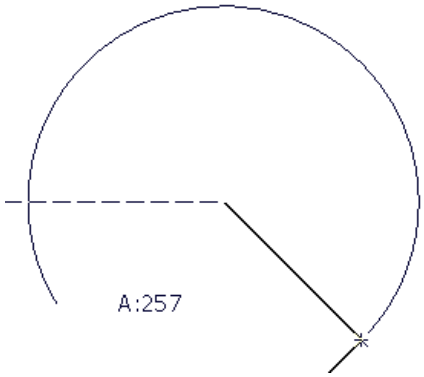
- **From** the **Arc Menu** select **Arc through centre**, **radius and span**.

- **Snap on** the **open end** of the **construction line**, for the centre point.
- **Move** the **cursor** to the **other end** of the **line** and **click** with the **left mouse button**.



The position is now set for the start of the **arc**.

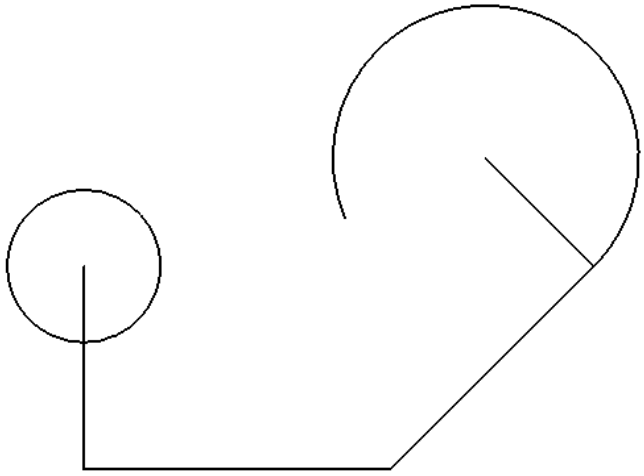
- **Release all mouse buttons** and **drag** the **arc around anti-clockwise**.



The **intelligent cursor** displays the current span angle.

When the left mouse button is clicked, the **arc** is created.

- **Click** the **left mouse button** when the arc reaches about **250 degrees**.

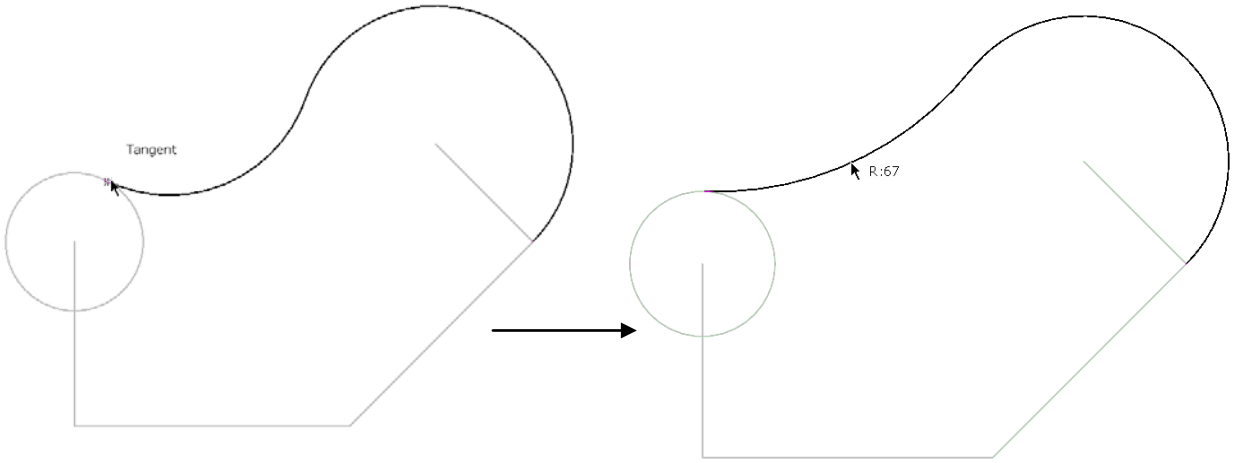


The blend radius (**R 60**) will now be generated using **Create an arc through three points**.

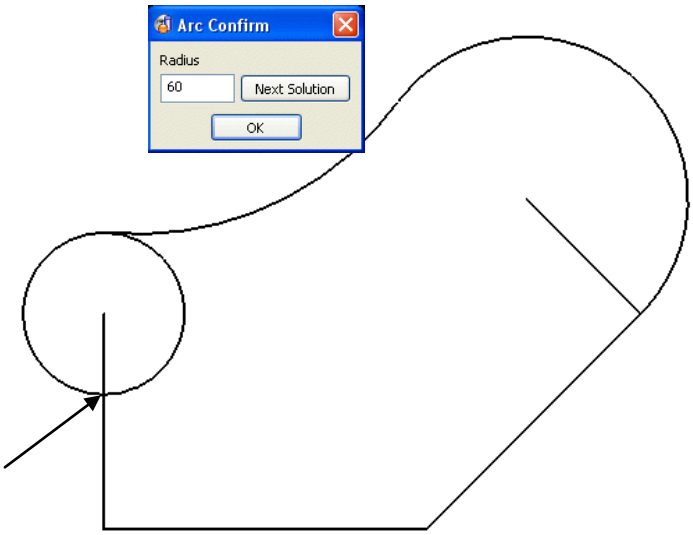
The 1st and 2nd points will be snapped as ***tangencies*** to the existing **full circle** and **arc** with the 3rd point being input as the specified blend radius value (**60**).

- **From** the **Arc Menu** select the **Arc through three points** option.

- Use the **intelligent cursor** to locate, and **Click** on **Tangent points** on the **arc** and **circle** (Do not locate a **Key**, **End** or **Mid point** as these are fixed positions).



- **Drag** the **radius point** to the required shape and to a value as close as possible to **60** before **left clicking** for initial **acceptance**.
- If necessary, In the **Arc Confirm** form **Modify** the **radius** value to **60** and toggle through **Next Solution** until the correct shape is achieved, before pressing **OK**.



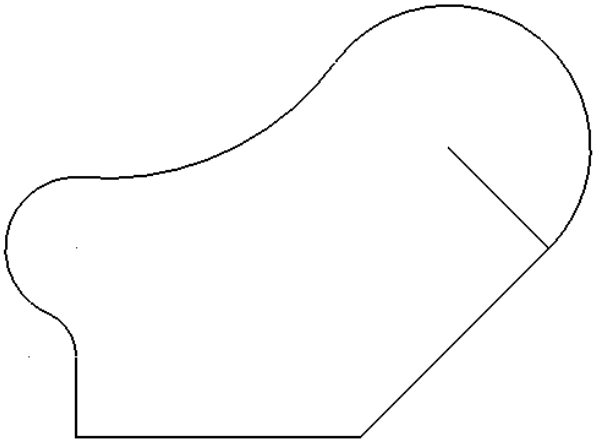
The new **arc** has been trimmed back both to the adjacent arc and circle.

The **Arc through three points** option will also be used to create the **R 10** fillet between the **line** running along Y and the remaining full **circle**.

- **Select** the **Arc through Three points** option.
- Use the **Arc through three points** option to create the **radius** of **10** between the **full circle** and the **vertical line**.

Composite Curves

In many applications it is necessary for the required **wireframe** to be a single entity. This is achieved by creating the wireframe as a **composite curve**.
Note:- A **composite curve** can only by driven along existing model entities.



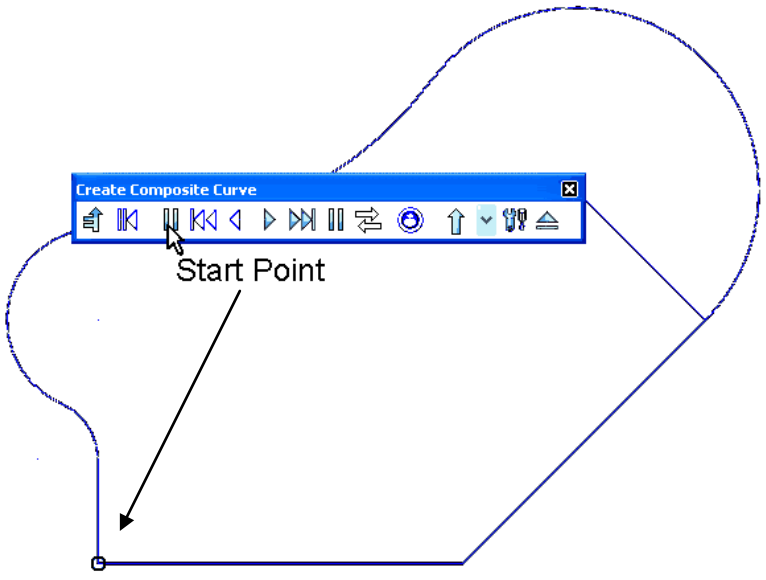
The basic **wireframe** shape now is complete but is currently made up of several separate **lines** and **arcs**.

The extent of a **composite curve** can be limited between selected **key** points along the potential route (**Define start point** and **Define end point**).

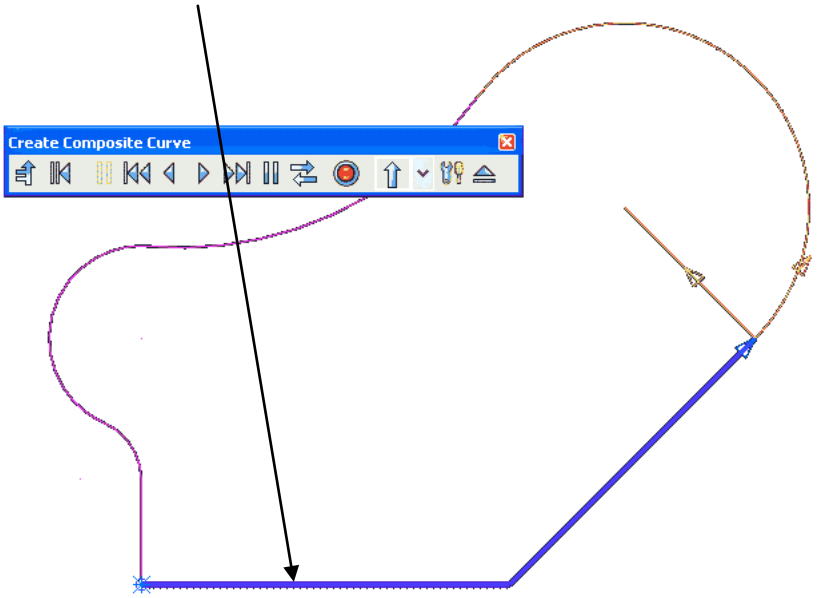
- From the **Curve Menu**, select **Composite curve**.

The **composite curve** toolbar appears.

- Select the **Start Point** option in the toolbar and ***left click*** the lower left corner on the **wireframe** model.



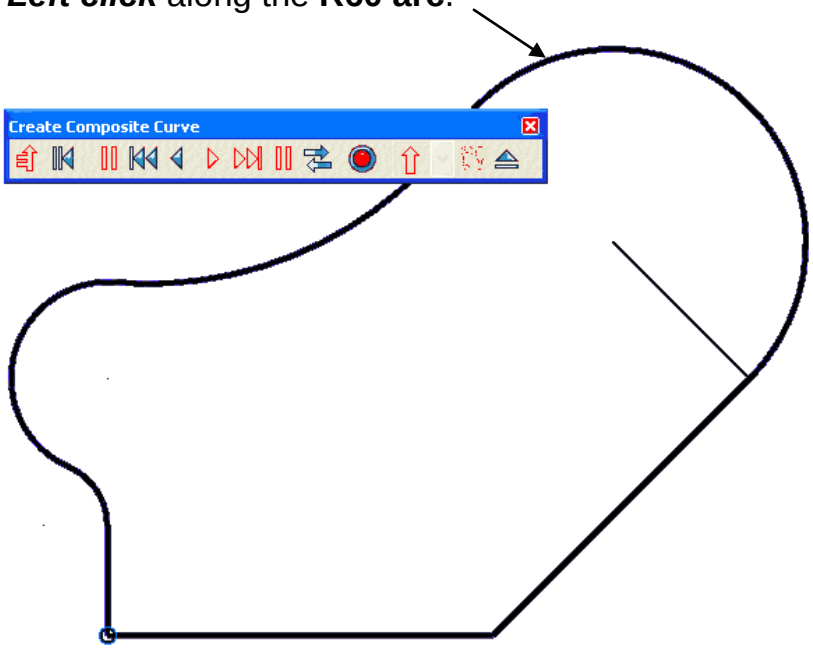
- ***Left click*** on the **bottom line**.



The **Composite Curve** is generated along the route until it hits a branch point where optional directions will be arrowed and change colour for the user to manually select the required route.

Note: The ***asterisk*** at the **start point** indicates that the **composite curve** is currently open.

- ***Left click*** along the **R60 arc**.

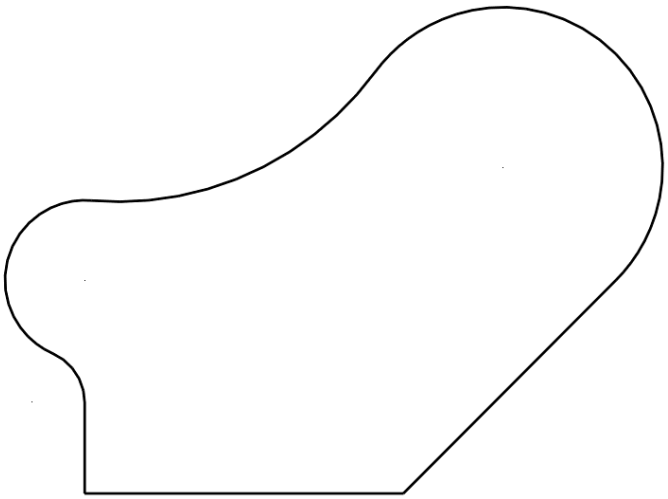


The **Composite curve** has now continued around the **wireframe** back to the defined **Start Point**.

Note: a *circle* at the **Start Point** indicates that the **composite curve** is a ***closed*** form.

- On the toolbar select **Save** to accept the **composite curve**.
- Select **Eject** to remove the toolbar.

- Select the **construction line** with the **left mouse button**.
- From the **right mouse button - menu**, select **Delete**.



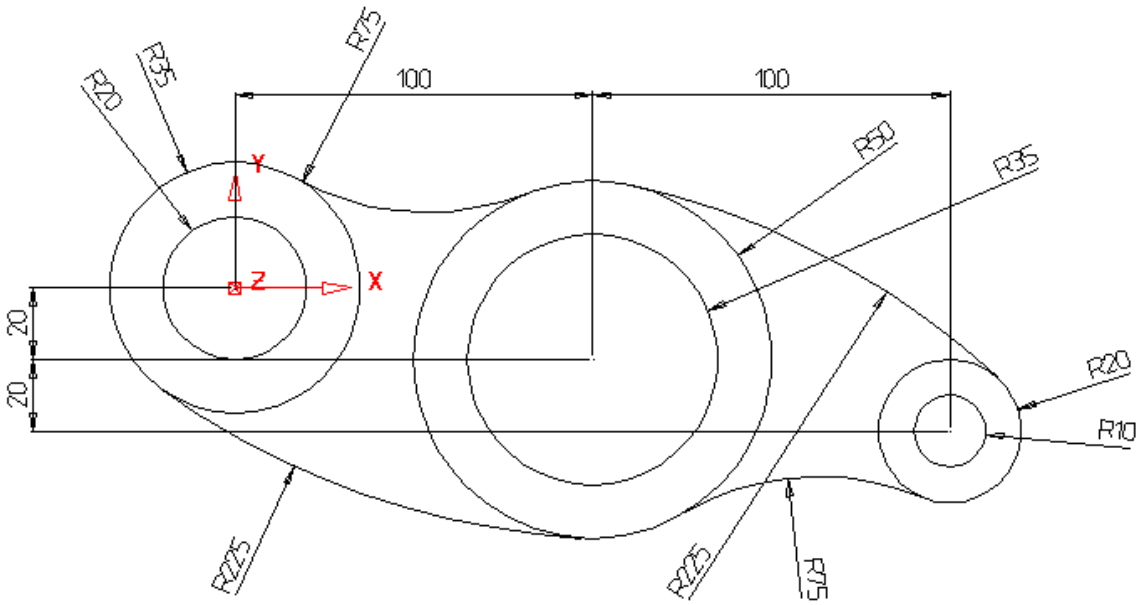
The **wireframe** is now complete and will be **Saved** as a permanent **model**.

- Select **File ➔ Save As**.
- In the form **Save the Model As**:-
  Save In:- **D:\users\training\Coursework**
  File Name:- **cam-example**

- Select **File ➔ Close**.

Wireframe Arcs Example

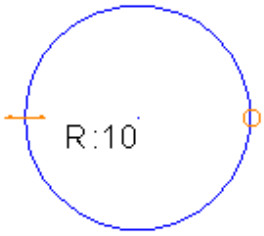
The next example demonstrates the use of **Arc**s to create the lever design shown below.



- **Select** the **Arc Menu**.
- **Select** the **Full Arc** option from the menu.

When this command is selected, the centre position of the circle is required first. This can be input as a value or by snapping using the **Intelligent Cursor**.

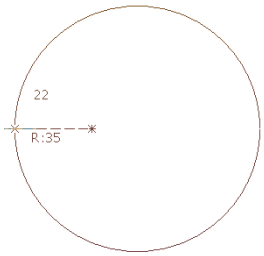
- In the **Command Input box** enter **0** for the circle centre and press return.



A preview of a circle has been generated with a **radius** input from the default value. The radius can be altered by dragging one of the displayed arrow to the required unit value.

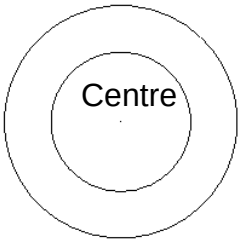
To accept the circle, press the **escape key**.

- With the **circle selected**, click and hold the handles (arrows) and dynamically move the mouse to **drag** a **new radius** of **35**.



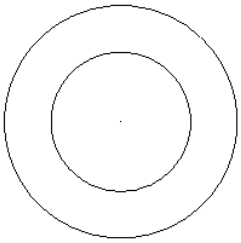
The **circle** now has the required **radius**. This method can be used to create the second circle at the same centre position, using the **Intelligent Cursor**. Alternatively the user can ***right click*** on the **arc** and select ***Modify*** from the local menu.

- **Select** the **Circle** command.
- **Position** the **cursor over** the **centre** of the **first circle** so the word ***Centre*** appears.
- **Click** the **Left mouse button** to accept the centre of the new circle.



This new **circle** is exactly the same initial radius as the first circle. To change the default, creation radius a new value is entered into the ***Command Input window*** i.e**. R 25**.

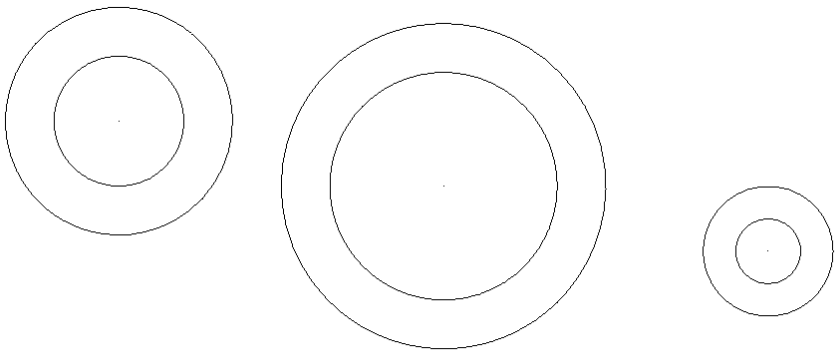
- **Drag** the second **circle** to a **radius** of **20mm**.



The two basic circles are completed. Further circles are required for this model.

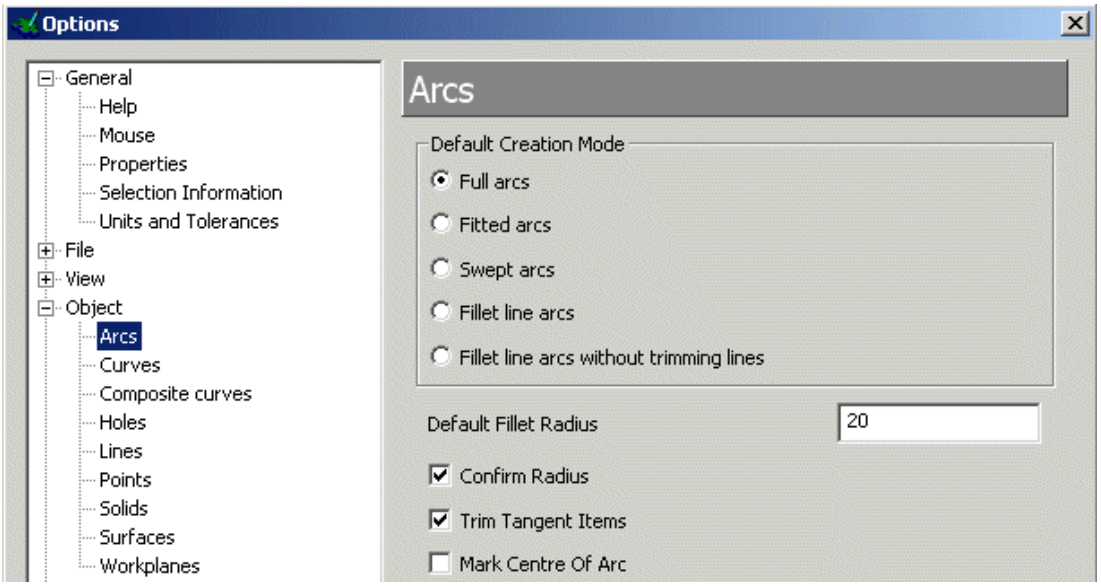
Hint: Use the command input box to enter the circle centre if it cannot be snapped.

- **Create** a **circle** at **centre 100 –20** with a **radius** of **50mm**.
- **Create** a **circle** at **centre 100 –20** with a **radius** to **35mm**.
- **Create** a **circle** at **centre 200 -40** with a **radius** of **20mm**.
- **Create** a **circle** at **centre 200 -40** with a **radius** of **10mm**.
- Press **Escape**.



The default option when creating tangent arcs is to trim back the associated geometry. In this case it is not required to do this, so the flag (**Trim Tangent Items**) is switched off. This is found in the **Options** form under **Tools** at the top of the screen.

- **Select Tools ➔ Options**, select **Object** then **Arcs**.

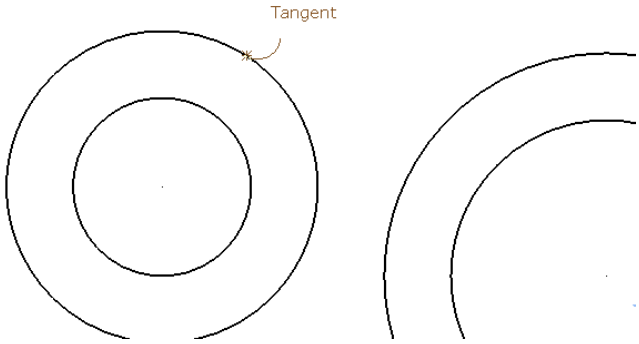


- *Untick* **Trim Tangent items**.

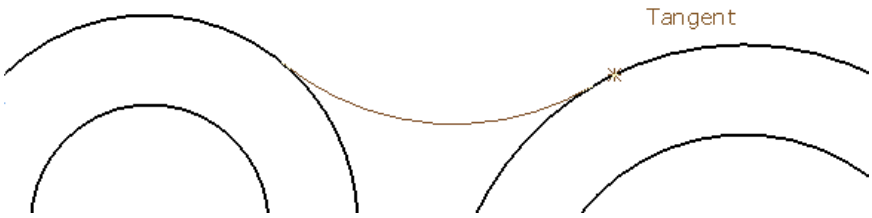
- *Press* **OK**.

For the tangent arcs, the fitted arc option is the most suitable as it provides full dynamic control through all possible combinations.

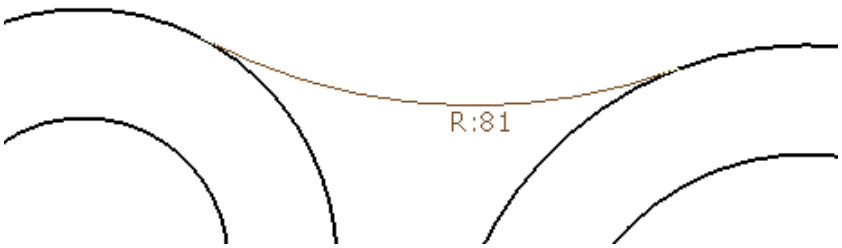
- From the **Arcs** menu select the **Three point arc** option.
- **Move** the **cursor over** the **outer left circle** until the word **Tangent appears** and **press** the **Left mouse button**.



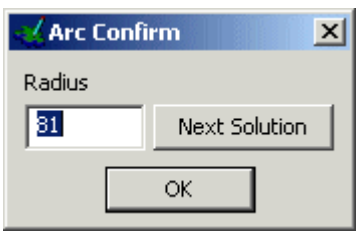
- **Move** the **cursor over** the **middle outer circle** so the word **Tangent appears** and **press the left mouse button**.



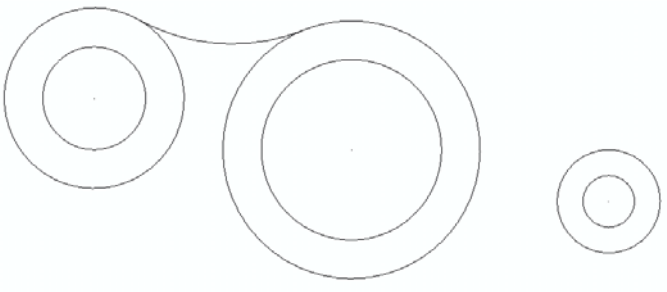
- **Move** the **cursor over up** and **down** to get the **tangent arc** in the correct place and **press** the **Left mouse button**.



The Arc Confirm form appears. This can be used to enter an exact radius.



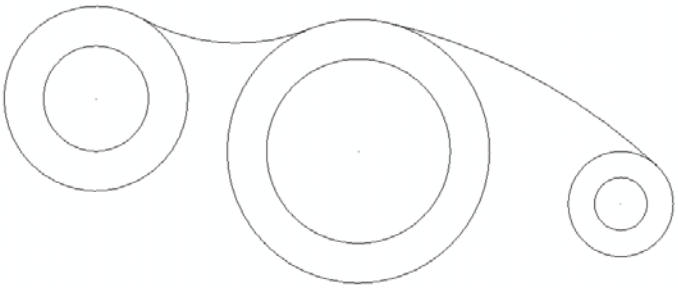
- **Enter** a **value** of **75** and press **OK**.



The tangent arc is drawn.

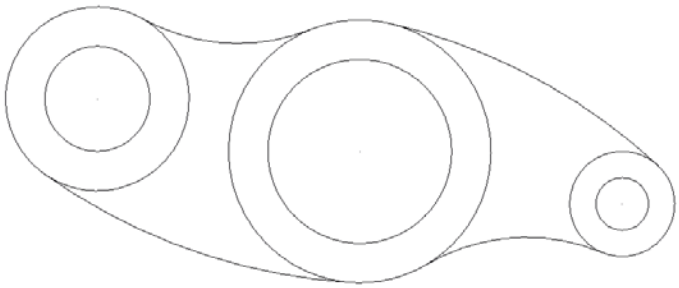
The command automatically repeats until exited by pressing escape or the selector.

- **Move** the **cursor over** the **middle outer circle** until the word **Tangent appears** and **press** the **Left mouse button**.
- **Move** the **cursor over** the **right outer circle** so the word **Tangent appears** and **press the left mouse button**.
- **Drag** a **radius** of **225** and **press OK**.



The second radius has been generated. The further two can be generated in the same manner.

- **Create** a **three point arc** between the **left outer circle** and the **middle outer circle** with a **radius** of **225mm**.
- **Create** a **three point arc** between the **right outer circle** and the **middle outer circle** with a **radius** of **75mm**.



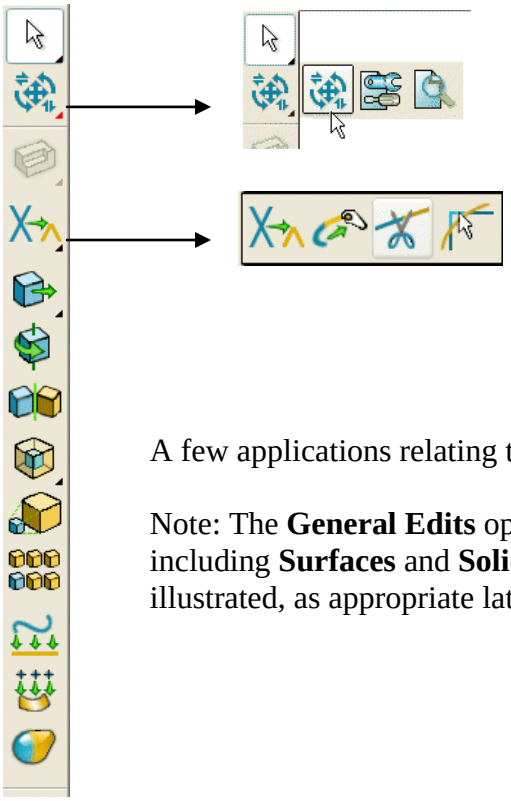
The model is complete. The option needs to be switched off and the wireframe copied to a new level.

- Select **File ➔ Save As**.
- In the form **Save the Model As**:-
  Save In:- **D:\users\training\Coursework**
  File Name:- **lever-example**

- Select **File ➔ Close**.

General Edits

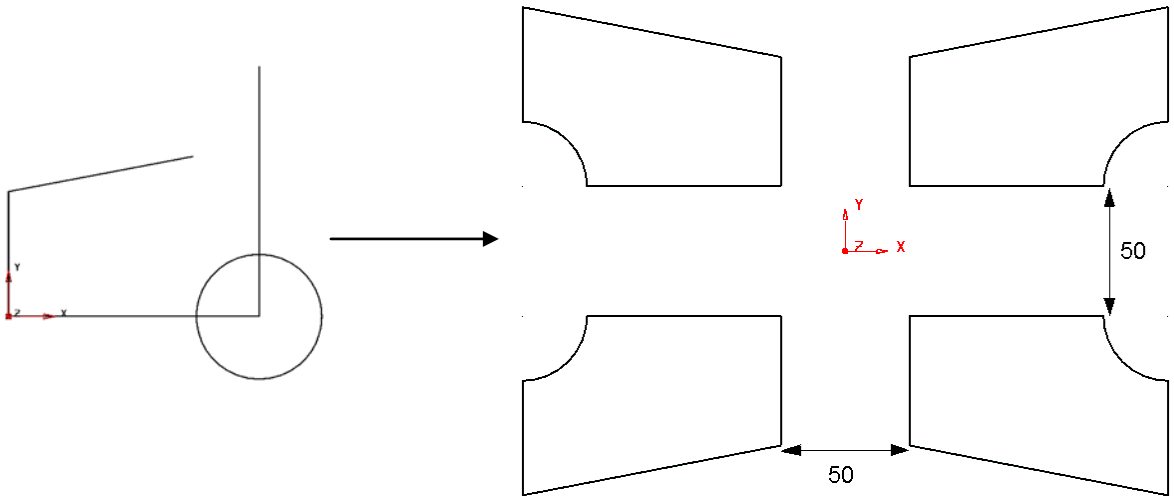
At the top of the left hand toolbar are 2 fixed icons, the second of which includes access to the **General Edits** toolbar (default).



A few applications relating to **wireframe** data will be illustrated in this section.

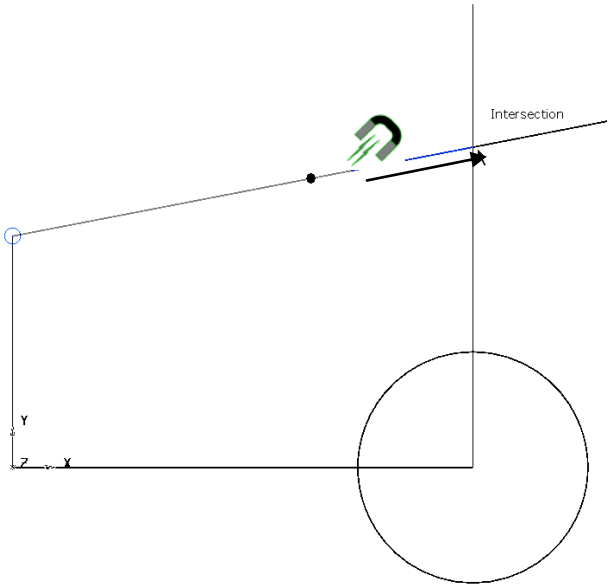
Note: The **General Edits** options are also frequently used on other entities including **Surfaces** and **Solids**. Further **General Edit** options will be illustrated, as appropriate later on during the course.

- **Close** the existing **Saved** model.
- Open a **New** model.
- Select **File - Import** and locate the **wireframe** model:- ***…..\PowerMILL Modelling_Data\psmodels_n_dgk\GeneralEdit_Wireframe.dgk***

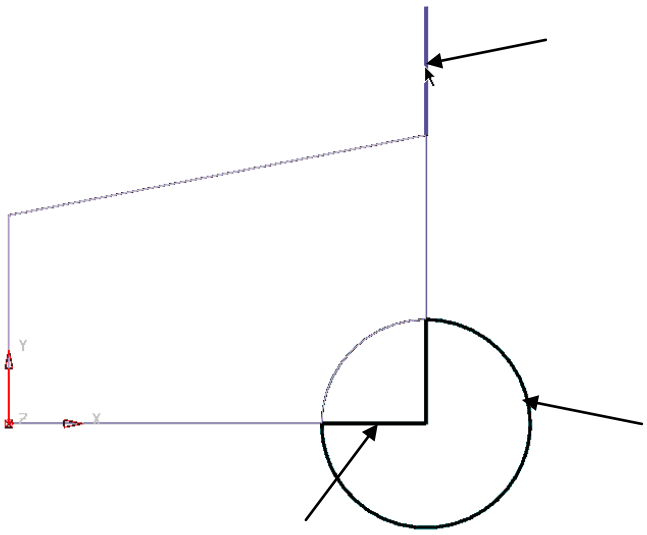


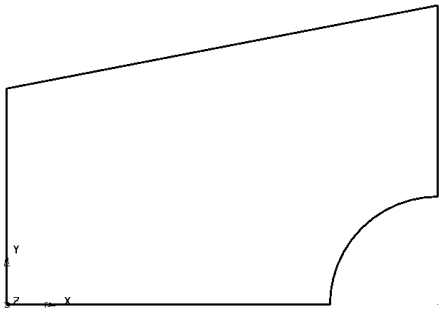
The imported wireframe (shown above left) will be modified using the **general edits options** initially to produce the 4 finished **wireframes** (shown above right).

- Select the **Point limit** option and move the cursor to the end of the line to be extended and hold down the left mouse key (The cursor will take the form of a magnet).
- Drag the end of the **line** tangentially (along the preview line) until the word **Intersection** is displayed at which point release the left mouse key,



- Select the **Interactively limit wireframes** option and left click the ***mid-span*** of any sections of the **wireframe** network that are to be trimmed away (as illustrated below).

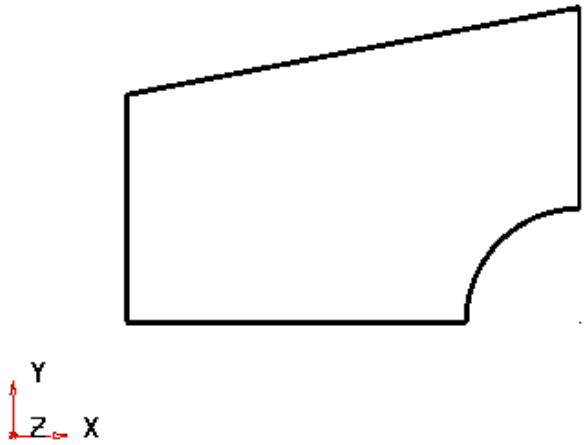




- Create a **Composite Curve** from the network of **lines** and **arc** wireframes (Hint: For a ‘shortcut’ method hold down the **Alt *key*** and **left click** anywhere along the **wireframe** network).

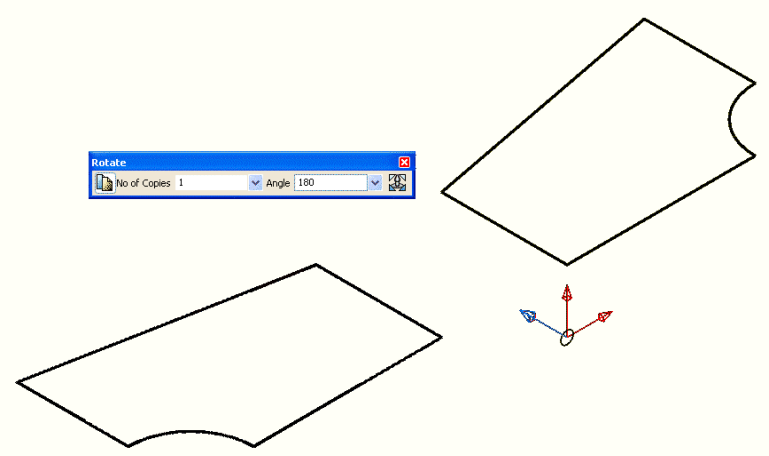
- With the **Composite Curve** selected, open the **general edit** - **Move** form.

- While the form is open, enter the coordinate values **25 25** in the **Command Input** box located at the bottom right of the graphics area.



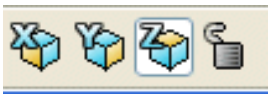
The **Composite Curve** is shifted by **25mm** along both **X** and **Y**.

- Select **Y** as the operational axis by selecting the Icon located below the graphics area towards the left hand side.
- With the **Curve** selected, open the **general edit** - **Rotate** form.
- In the **Rotate** form select the ***keep original*** option , enter ***No of Copies***:- **1**, and ***Angle***:- **180** followed by **Return**.



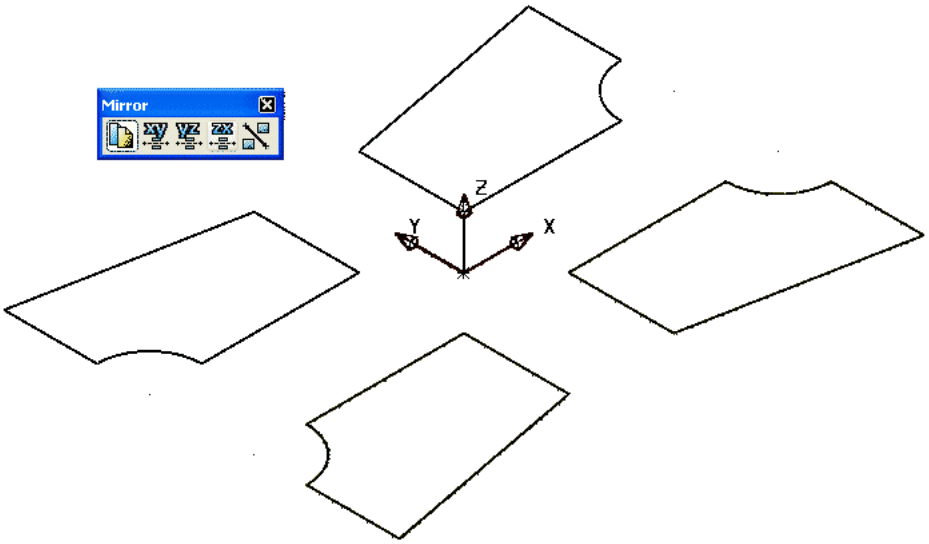
A copy of the **composite curve** has been **rotated** by **180** degrees about the active **Y** axis.
Note:- In this case the same result would have been obtained if the curve had been **mirrored** about the **YZ** plane.

- Reinstate **Z** as the operational axis by selecting the Icon located below the graphics area towards the left hand side.



- With both **Curves** selected, open the **general edit** – **Mirror** form.

- In the **Mirror** form select the ***keep original*** option and select the icon labelled **ZX** followed by **Return**.

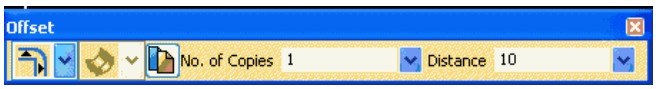


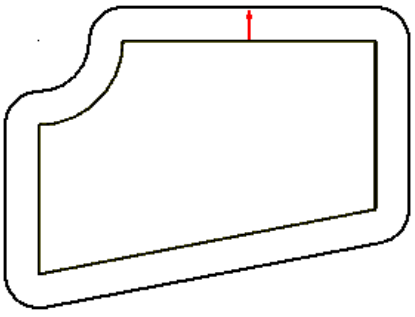
Copies of the 2 **composite curves** are **mirrored** about the active **ZX** plane.

Further General Edit options

Offset

- Select the **composite curve** located in the **-X -Y** quadrant and in the **General Edits** form select the **Offset** options.

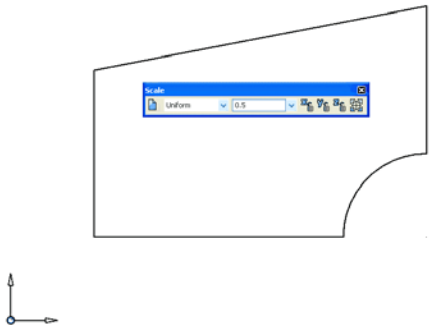




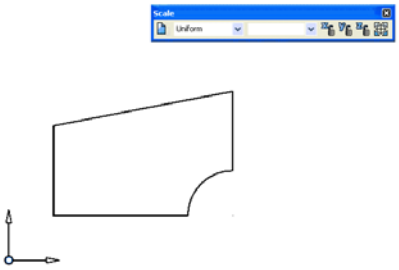
- Select the **Round discontinuities** option and input ***Distance* 10** to create an **offset copy** as shown above (The arrow denotes the offset direction for a +ve **Distance** value).

Scale

- Select the **composite curve** located in the **X Y** quadrant and in the **General Edits** form select the **Scale** option.

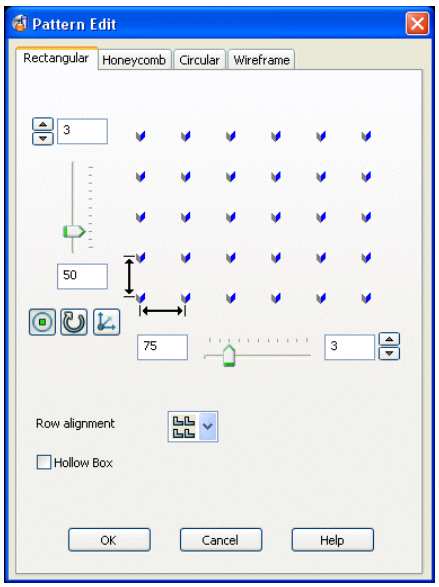


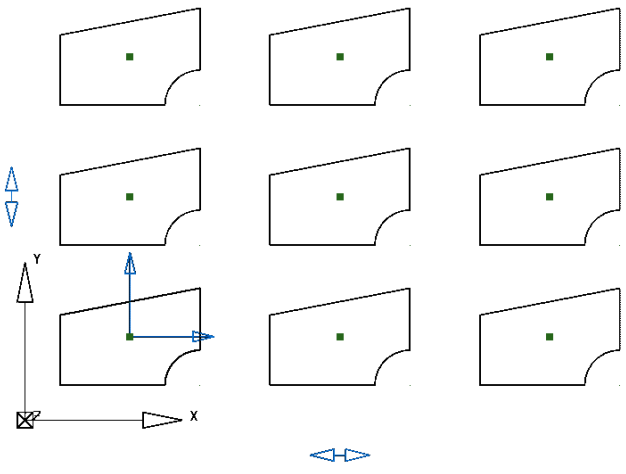
- Enter a ***Scale*** factor of **0.5** to reduce the size of the **composite curve** by **50%** of the original size (as shown below).



Create Pattern of objects

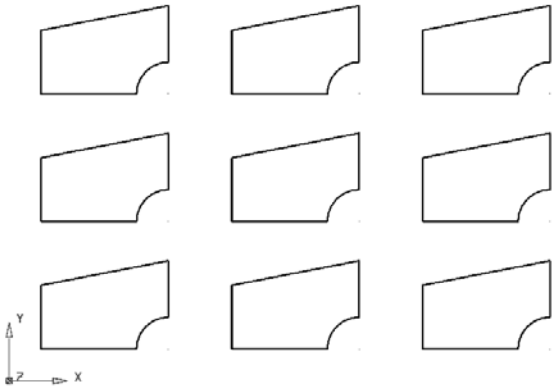
- With the scaled down **composite curve** still selected, click the **Create Pattern of objects** option.



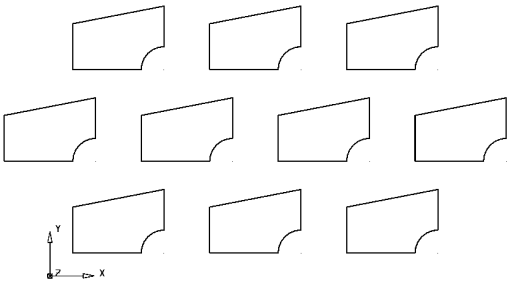


The current settings are immediately previewed.

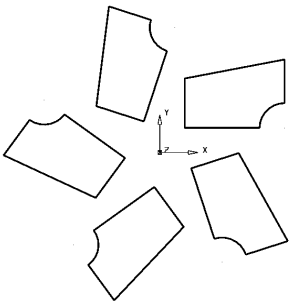
- Input **3** rows along both **Y** and **X** with a **Y pitch** of **50** and **X pitch** of **75**.
- Select **OK** to accept.



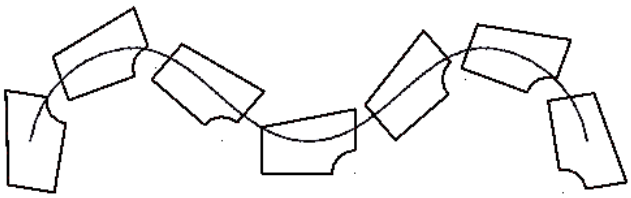
Rectangular is one of 4 main functions in the **Pattern Edits** form. The other 3 include **Honeycomb**, **Circular**, and along **Wireframe**. Note: Within each specific **Pattern Edit** form further advanced options are available.



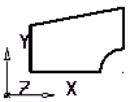
Honeycomb



Circular



Wireframe



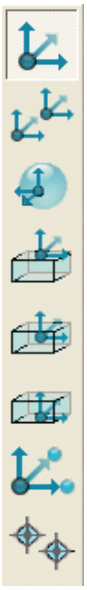
The **General Edits** options will be applied as required, later during the course on other **PowerMILL Modelling** entities such as **Surfaces** and **Solids**.

3. Workplanes

Workplanes

Workplanes are user, defined datums, positioned and aligned as required to simplify model creation. A model can contain several **workplanes**, but only one can be **Active** at any time. When a **workplane** is **Active** it becomes the **XYZ** datum, visually larger in size, and changes colour from grey to red. Model entities can be **copied** or **cut** from the currently **Active workplane** and then **pasted** back in a different position, relative to a new **Active workplane**.

The main **Workplane** icon is located in the main toolbar which when selected will provide the following icons in the left hand toolbar:



Single Workplanes.

Multiple Workplanes.

Single workplane aligned to geometry.

Single workplane at top of selection.

Single workplane at centre of selection.

Single workplane at bottom of selection.

Workplane from three points.

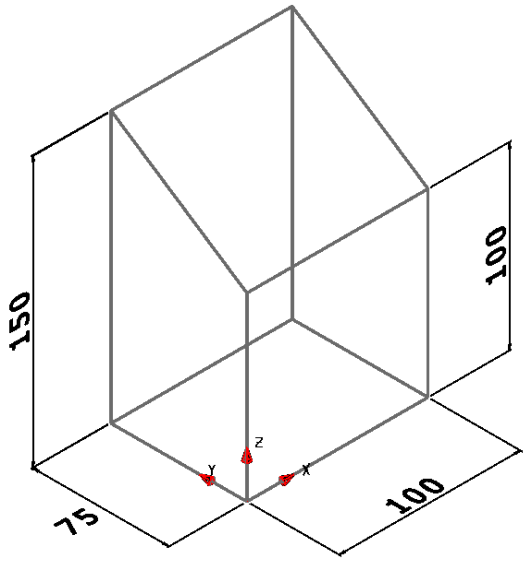
Create Points.

In the next example the user will be required to apply **wireframe Lines** to construct a box with an angled top. This in turn will be used as the model to demonstrate some basic applications of **workplanes**.

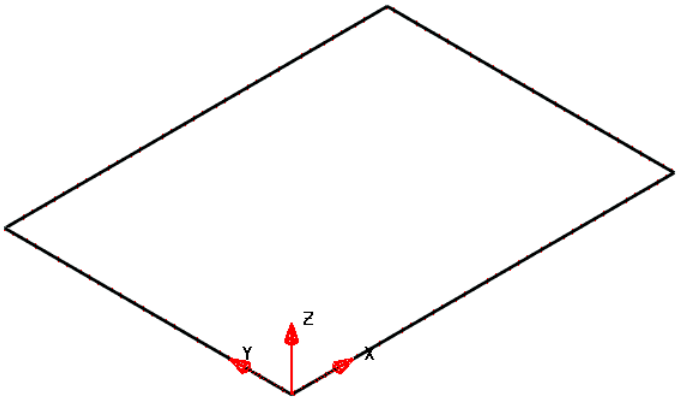
Box Example

- Open a **New Model**.

The **wireframe** for the dimensioned form (as shown right) will now be created.

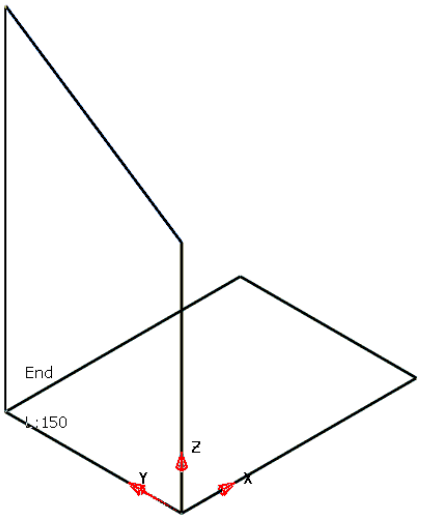


- Open the **Single Workplane** option and enter **0** into the **Command Input** window to position it at the ***World Datum***.
- Select the **view Iso1**.
- **From** the **Line** menu select **Rectangle**.
- Enter **0** in the **Command input box** and press **Return**.
- Enter **100 75** in the **Command input box** and press **Return**.



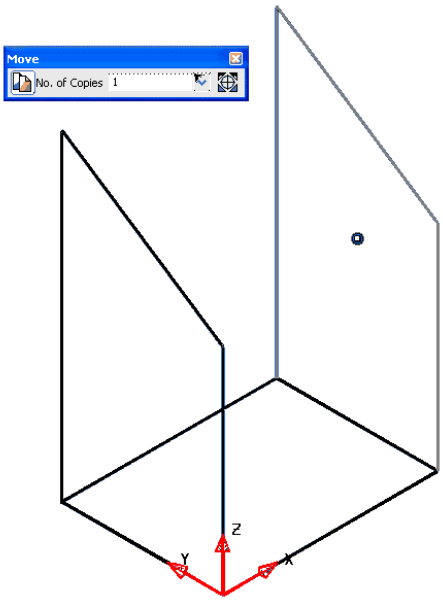
Note:- The ***rectangle*** is not a single entity but consists of 4 separate, **wireframe lines**.

- From the **Line** menu select **Continuous Lines**.
- **Snap** the start of the **line** onto the **Workplane**.
- Enter **0 0 100** in the **Command input box** and press **Return**.
- Enter **abs 0 75 150** in the **Command input box** and press **Return**.
- Snap (left mouse click) the end of the current line to the top left corner of the **rectangle** (Marked as ***End*** by the **Intelligent Cursor** below).



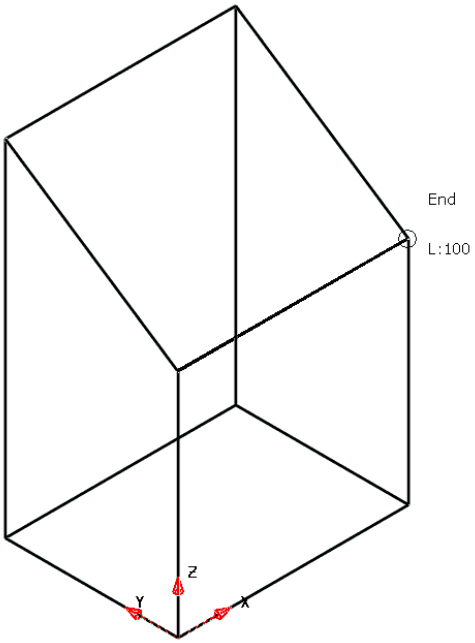
- Select the last 3 **lines** created.
- Open the **General Edits - Move** option.

- Select the option **Make a Copy** and enter **100** in the **command input box** before pressing **Return**.



The final 2 **Single lines** are input by snapping to appropriate key points on the wireframe model.

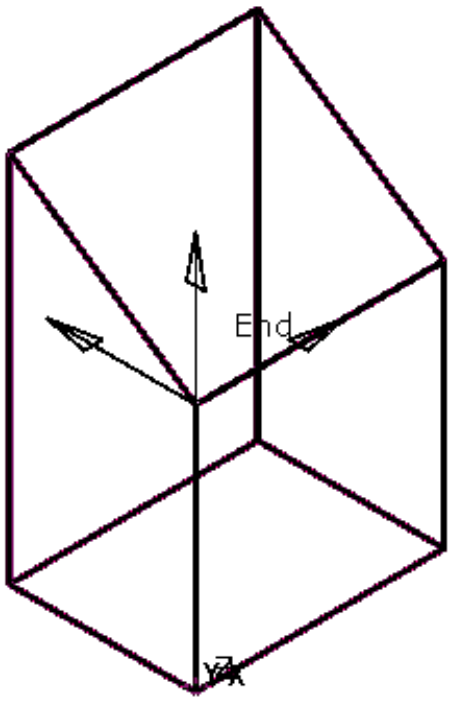
- Select **Single Lines**.
- Press **Escape**.



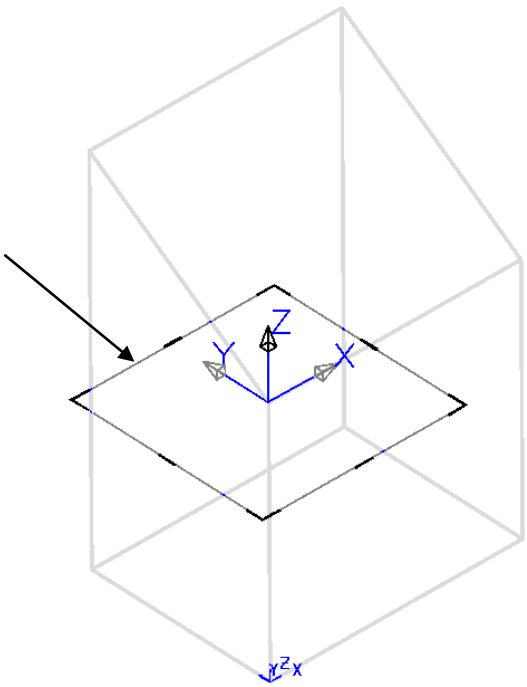
The main **wireframe *model*** is now complete.

An additional **wireframe *model*** based on a hexagonal **Polygon of lines** will now be created to a new **workplane** coordinate system at **X -100** away from the main model. ***A*** copy of this separate model will later be placed onto the angled, top face of main model.

- Open the **Single Workplane** option and ***snap*** a new **workplane** to the top ***End*** of the line running up **Z** from the original **workplane**.



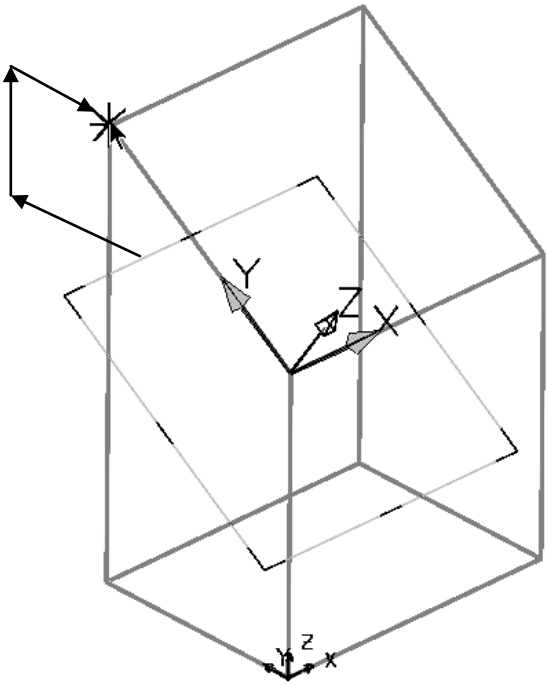
- **Zoom** into the new (**Active**) **workplane** and then use the left mouse key to ***select*** it.

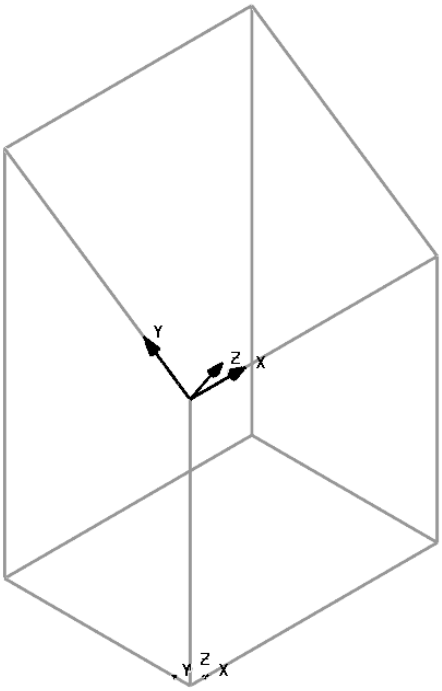


When a **workplane** is selected a square appears on the **XY** plane. The corners and mid points of the square, along with the **Z** axis arrowhead are thicker and darker in colour.
If the left mouse key is held down on one of the dark bands then the **workplane** can be dynamically rotated about the **Z** axis.
If the left mouse is held down one of the lighter coloured bands then the **workplane** can be dynamically rotated about the corresponding, ***parallel*** **X** axis or **Y** axis.

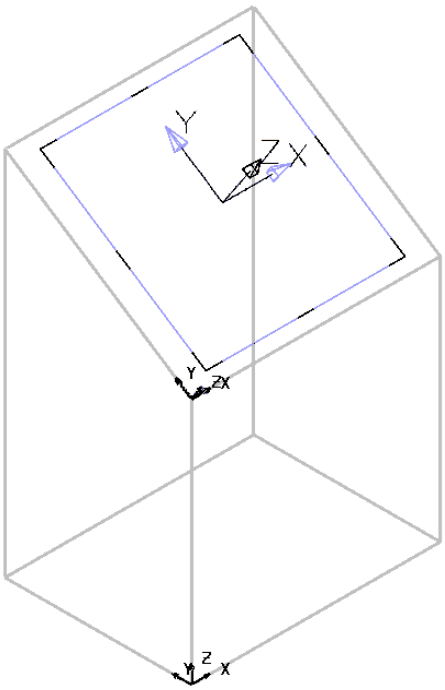
Note: If one of the **workplane** ***arrowheads*** is selected (instead of a coloured band) during dynamic re-orientation then all **workplane** axes will rotate simultaneously.

- Select the light band on the **+Y** side and parallel with the **X** axis and with the left mouse key depressed drag and drop on to the upper left corner of the model (arrowed above).



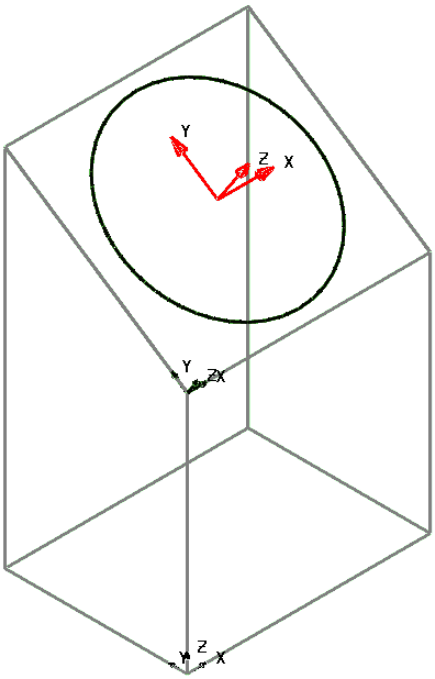


- Select the 4 **lines** enclosing the angled top face of the model and select the **workplane** option - ***single workplane at centre of selection***.



As soon as the icon is clicked a new **workplane** is created, central to the 4 selected **lines**.
This **workplane** will both be **Active** and **selected**.

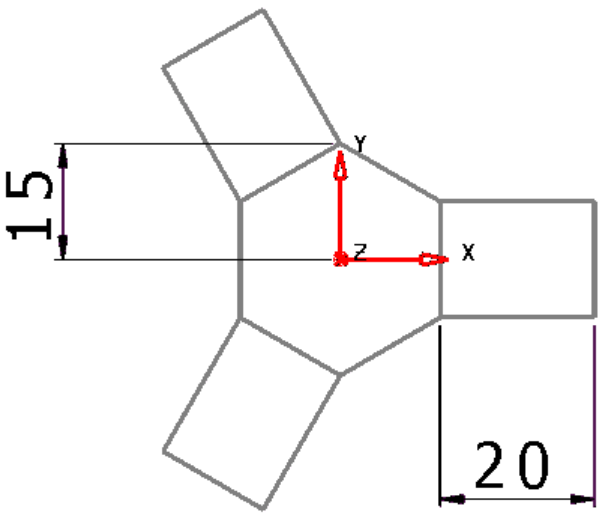
- From the main toolbar select the **Arc** options and create a **40 radius** - **Full Arc** about the currently **Active workplane**.



The **R40 Circle** has been created on the **XY** plane of the **Active workplane** central to the angled top face of the **wireframe** model.

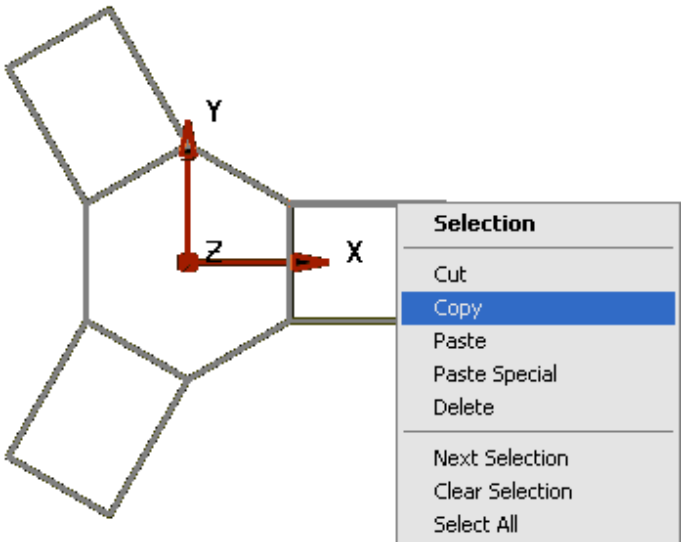
- Right click on the ***Active*** **workplane** to open it's local menu and ***untick*** **Activate**. As no **workplane** is now **Active** all measurements will now be controlled by the original **World** coordinates.

- Open the **Single Workplane** option and enter **-100** into the **Command Input** window to position it (along **-X**) away from the main model (The new **workplane** will become **Active** by default).
- Create the following network of **wireframe lines** central to the new **workplane**.



This **wireframe** will be copied from the local **workplane** to the ***workplane*** central to the angled face on the main model.

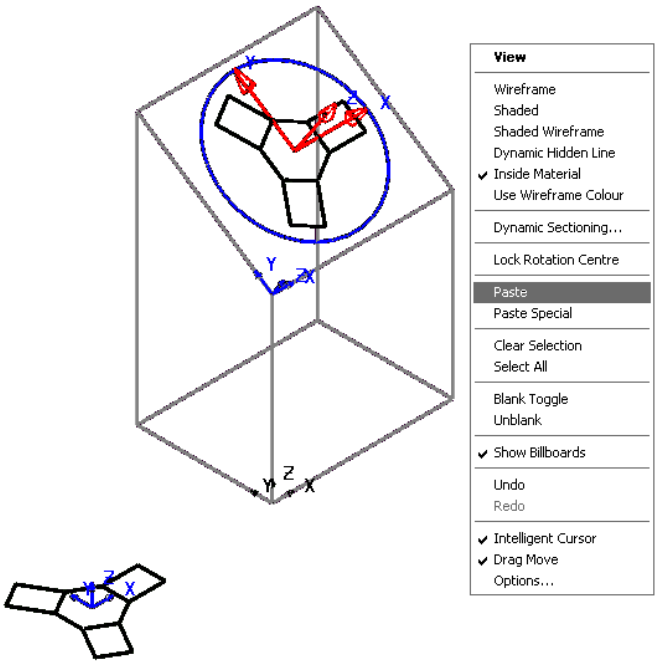
- With the above **workplane Active**, select all the new locally created **wireframe** and with the cursor on one of the **lines**, right click to open the local **Selection** menu.



- Select **Copy** in the menu.

The selected **wireframe** is effectively, copied via the mouse!

- **Activate** the **workplane** positioned central to the angled, top face on the ***main*** **wireframe** model.
- Right mouse click in the graphics area away from the model and select **Paste** from the local menu.



The **wireframe** created away from the main model has been copied relative to the **workplane** central to the top angle face of the **main wireframe** model.

Note: Data relative to an ***Active*** **workplane** in one PowerMILL MOdelling model can be **copied** and **pasted** relative to an ***Active*** **workplane** in a different PowerMILL MOdelling model

- From the **main** pulldown menus select **File – Save As**, and store the ***psmodel*** as **D:\users\training\Coursework\Workplane-Box**

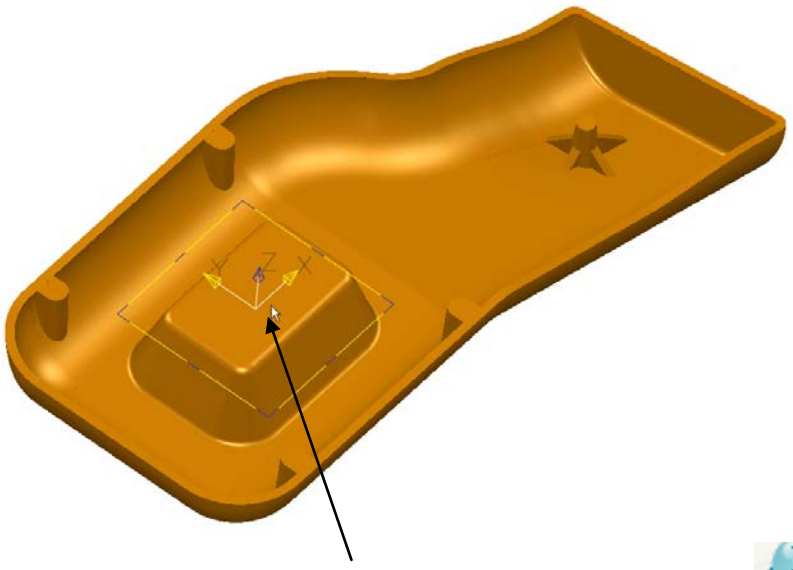
Workplane alignment of moulding component

Often when a component design is imported it will not be in a suitable orientation for such tasks as creating a tool around it, or for maximum accessibility to a 3 Axis machining operation. In these cases **Workplanes** are easily applied to achieve a more suitable location and orientation for the model. To maintain dimensional accountability to the original component, it is essential to move **workplanes** around the model as opposed to physically moving the model relative to the **world** datum

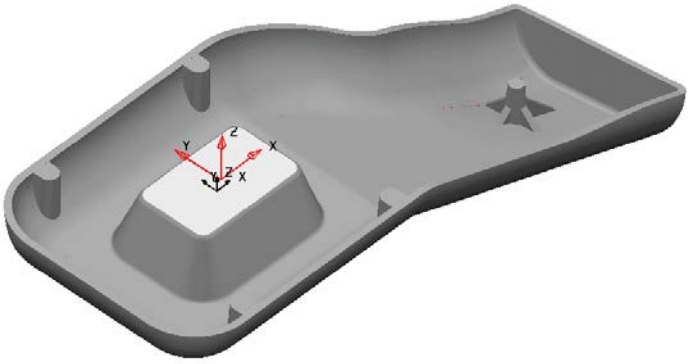
- Select **File - Import** and locate the **Surface** model:- ***…..\PowerMILL MOdelling_Data\psmodels_n_dgk\Interior-Trim.dgk***

The imported model of a plastic moulding is not in a suitable orientation from which to create a mould tool. As a result a suitably positioned **workplane** will be created to provide an appropriate tooling datum. The most obvious choice for a tooling alignment is ***normal*** to the base of the pocket.

- Use the ***middle*** mouse key to dynamically rotate the view to display the underside of the component.

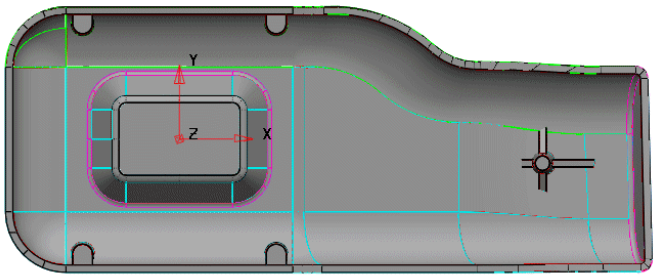


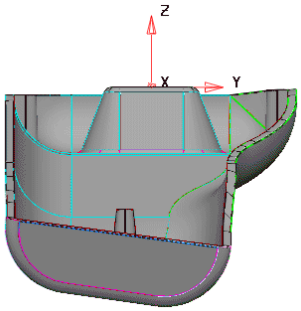
- Open the **Single workplane aligned to geometry** option and left mouse click on the **surface** defining underside face of the pocket.
- Select the surface defining the underside face of the pocket again and select the **Single workplane at top of selection** option.



The latest **workplane** will be positioned, exactly central to the selected **surface**.

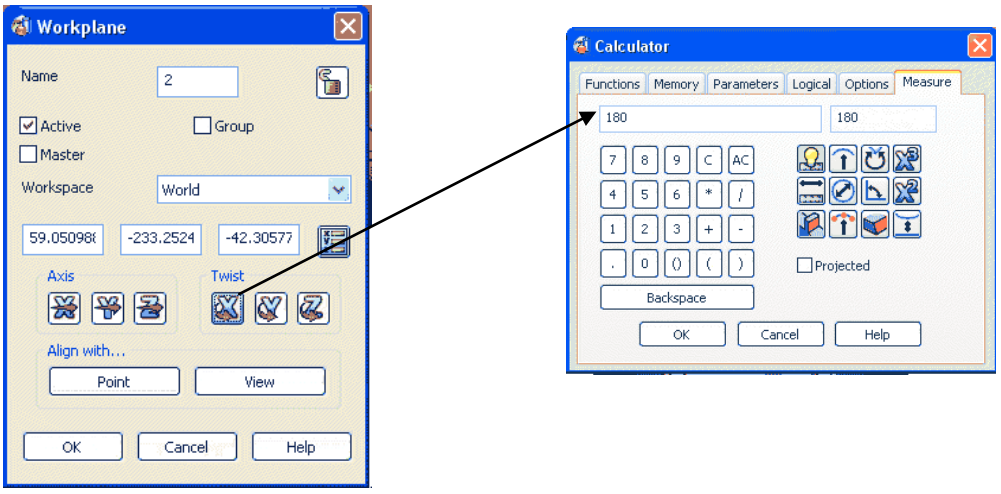
- Select and **Delete** the original **workplane** used to create the alignment with the base of the pocket.
- View the model in all directions to check that a suitable tooling alignment has been achieved.



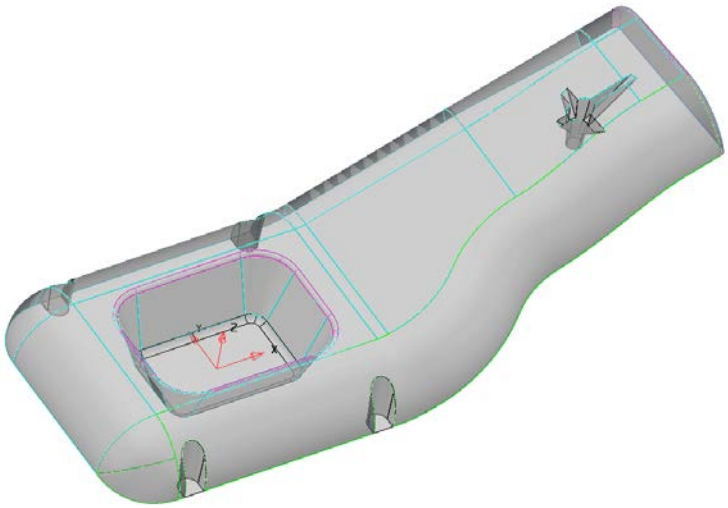


It is possible that the model may need to be rotated 180 Degrees about the **X Axis** at some stage. This can be performed using the **workplane** editing form.

- Right mouse click on the **workplane** and in the local menu select **Modify**.



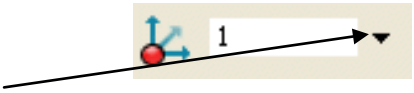
- Select the ***Twist* X** icon and enter **180** in the **Calculator** form before selecting **OK**, and then **OK** again in the **Workplane** form.



The model is now turned the other way up relative to the **workplane** orientation.

Workplane toolbar

Below the graphics area in the bottom left hand corner is the workplane toolbar, which includes an icon for creating temporary workplanes as well as a table as an alternative means to control the naming and activation of workplanes.

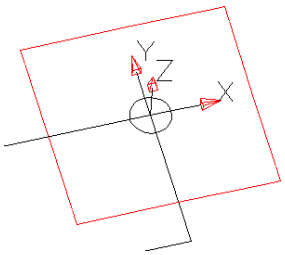


- Select the **down arrow** to select another workplane.

If **workplane 1** is selected in the form it becomes active. A **workplane** can be renamed by clicking on the current name and typing over it with the new name, followed by the return key.

- Click on the **Temporary Workplane** icon.

- Snap to some existing geometry (or anywhere in the graphics area).



The red and black temporary **workplane** appears. This **workplane** does not have access to a local editing form, but can be modified using the **General Edit** toolbar options. It is automatically called **Temporary** and can be deleted from using the local menu or by pressing the **Temporary Workplane** icon.

- Click on the **Temporary Workplane** icon.

The **Temporary workplane** is removed from the model.

- Select File ➔ Close.

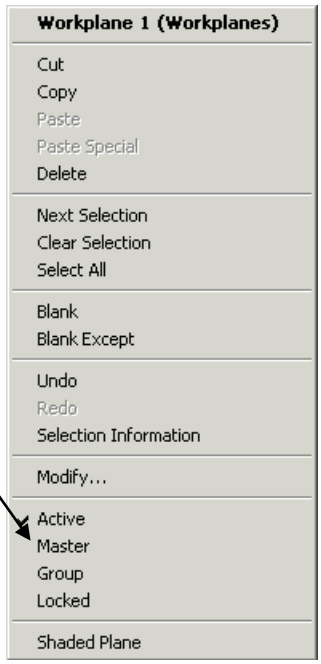
Master Workplane

In a PowerMILL MOdelling model one of the **workplanes** can be designated as the **Master**, which will be displayed with thicker lines to distinguish it from the others.
If another active **workplane** is deactivated, instead of PowerMILL MOdelling reverting to the **World** co-ordinate system it activates the **Master Workplane**.

Example

- Open the model **golf_fin.**

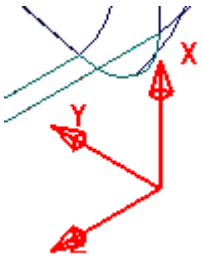
There are two Workplanes on this model called 1 and 2.These are situated above the World Co-ordinate system in the workplane menu.



- Select **Workplane 1** and click over it with the **right** mouse button to bring up the local menu.
- Select the option **Master** (this becomes ticked).
- **Deselect** the **workplane** to display the master status. (drawn in bold red).

The **workplane** also appears below the World in the Workplane selector, so it is easy to find.

- **Activate** workplane **2** and then **deactivate** it.



The master workplane becomes active, instead of the world origin. This is especially useful for users handling imported data in the car industry where traditionally every component part has a common datum (Car Line). This World datum could be metres away as well as being in an unsuitable orientation for tooling purposes. It must however be retained in case a copy of the data is to be returned to the supplier (in Car Line).

- Select **File ➔ Close**.

4. Surfaces

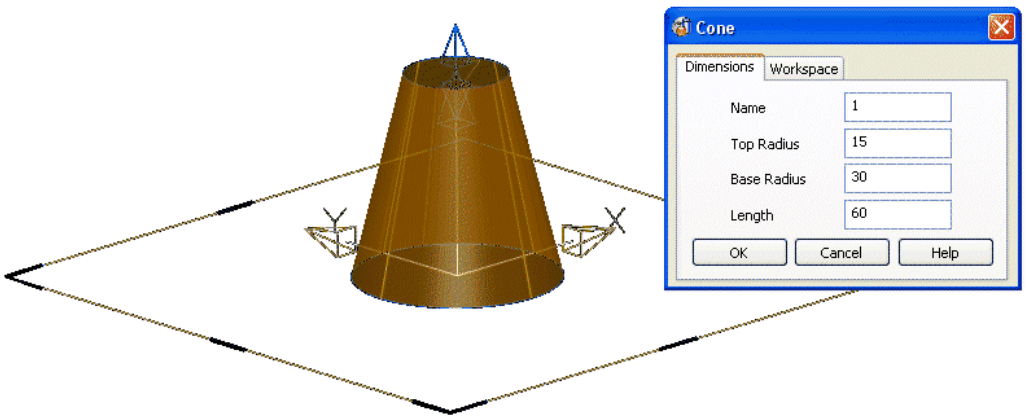
What is a Surface?

A **surface** is best described as a skin of negligible thickness stretched across a defined 2D or 3D area.
There are 3 main types of **surface** supported by **PowerMILL Modelling** which include:- **Primitives**, **NURBS** and **Power Surfaces**. The constructional attributes and editing capability of these are very different.

Primitive surfaces

A **Primitive Surface** is based on simple, ***standard shapes***, and ***wireframe extrusions*** or ***rotated*** forms. A **Primitive Surface** is defined or edited by entering set parameters into a specialist form (The actual input criteria depends on the type of **Primitive Surface**).
A major restriction of a **Primitive surface** is that it is only possible to modify the existing defined parameters such as ***length***, ***radius***, ***orientation*** and where applicable, the ***original wireframe***. **Primitive surfaces** also have an inherent workplane like datum, which the user can manipulate to perform modifications dynamically.

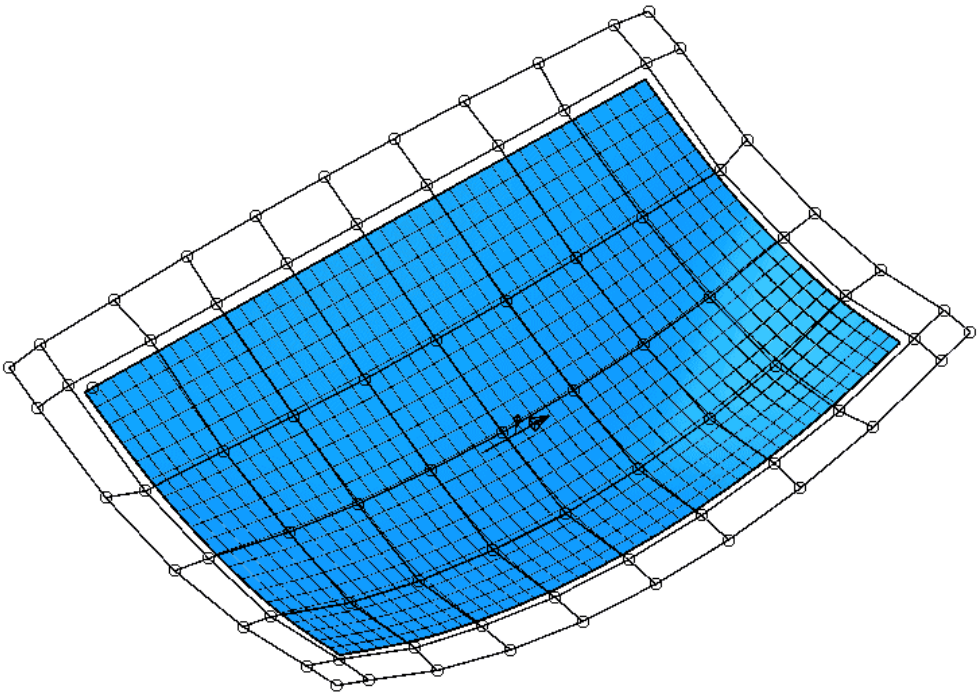
PowerMILL Modelling - Primitive surface options include:-
Primitive - ***Plane, Block, Sphere, Cylinder, Cone, Torus. Helix***.
Extruded surfaces (From pre-defined wireframe).
Surfaces of revolution (From pre-defined wireframe).



The **Primitive Cone** is shown left **selected** with the local **Cone** editing form open.

NURBS surfaces (Non-Uniform Rational B-Spline)

It is common for a **surface model** created using a different CAD system to be imported into **PowerMILL Modelling**. For this to be possible, **PowerMILL Modelling** supports other types of **Surface** definitions such as **NURBS surfaces**. **PowerMILL Modelling** will also create **NURBS surfaces** during certain applications or if dictated by the user in the **PowerMILL Modelling - Surface Options**.



The control points on a **NURBS** surface can be dynamically moved around in space, but not to any degree of dimensional accuracy.
Any such changes are tricky to apply and depend on the users' visual acceptance of the new form.

Conversion of Primitives and NURBS to Power Surfaces

If it is required to perform more complex modifications to the shape of a **Primitive** or **NURBS surface**, it must first, be **converted** to a **Power Surface**. With a **Power Surface** the user has access to a full range of editing options via a comprehensive **surface/curve editing** toolbar or **dynamic** operations.
Note:- It is not possible to ***convert*** a **Power surface** back to a **Primitive** or **NURBS** type.

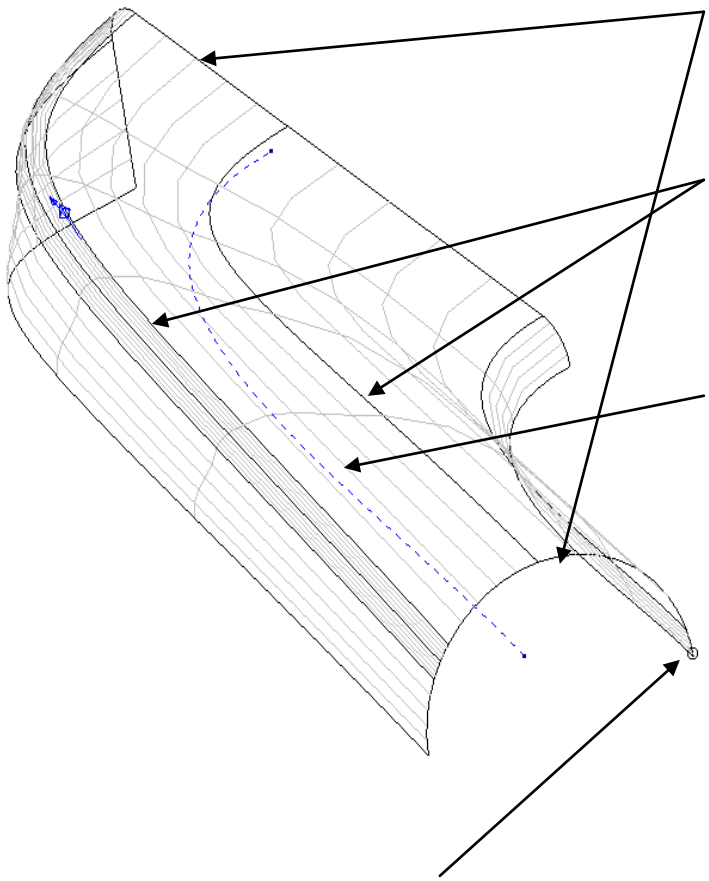
In the **Main** pulldown menu option:-
Tools – Options – Objects – Surfaces ensure that in the section labelled ***Primitives*** that **Create as NURBS** is unticked if direct conversion from **Primitives** to **Power Surfaces** is required (Otherwise when **Convert Surface** is applied to a **Primitive** it becomes a **NURBS** which in turn will have to be converted to a **Power Surface**).

Note:- Several of the **Surface** creation options directly create a **Power Surface**.

Power surfaces

A **Power surface** is based on a network of 4 sided **wireframe** elements appearing as curves along (**longitudinals**) and across (**laterals**) the surface area.
A **Power Surface** can generate complex forms while retaining ***full editing capability*** including the **direction** and **magnitude** through **surface curve** intersections.
To define holes within the **surface** area or an outside profile not compliant with a 4 sided **wireframe** structure, specialist ***trim curves*** called **Boundaries** are applied.
The area of **surface** between adjacent pairs of **laterals** and **longitudinals** is called a *patch*.

The curves on a **POWER Surface** are called longitudinals (along the surface) and laterals (across the surface). In some cases another (optional) curve exists called a spine. This generally runs along the longitudinal direction, often in free space controlling the orientation of the laterals.



Laterals
This surface contains the minimum, two laterals.

Longitudinals
This surface contains a total of 7 longitudinals flowing from corresponding points from the first to the second lateral

Spine (Drive Curve)
The spine (shown dotted) is used to control the orientation of the laterals. A spine is not mandatory and can be created or deleted as required without changing the surface shape. It occurs automatically such as during the creation of Fillet surfaces or as part of the controlled geometry of a Drive Curve surface.

The 'Kato' mark identifies the start point for Laterals and Longitudinals on a POWER surface. It is positioned a short distance from point 1 along lateral 1 with a short line pointing from it representing the Longitudinal direction.

5. Primitive Surfaces

Primitive Surfaces

PowerMILL Modelling can quickly create a range of simple surfaces defined by a few basic parameters. These are **Primitives**, **Extruded Surfaces** and **Surfaces of Revolution**. On **Primitive surfaces** only the basic dimensional parameters can be modified and the original defined shape cannot by altered. Other types of **Surfaces** used in **PowerMILL Modelling** include **Nurbs Surfaces** (Frequently obtained from imported data) and **Power Surfaces**. **Nurbs Surfaces** also have limited editing capability and along with **Primitive Surfaces** must first be **Converted** to **Power Surfaces** for a more powerful, comprehensive editing capability. Note: The conversion process is not reversible.

Standard Primitive Surfaces

There are **6** standard **Primitive Surfaces** options in **PowerMILL Modelling**, a **Plane**, a **Box**, a **Sphere**, a **Cylinder**, a **Cone** and a **Torus**. **Primitive Surfaces** are generated with minimal data input and can be an ideal starting point for many applications. **Primitives** are coloured gold in the pull down menu to distinguish them from other surface creation options.

Each **Primitive**, when created is given a size proportional to the zoom of the screen and are then, subsequently modified as required. A **Primitive** can be **moved**, **copied**, **rotated**, **intersected** and **filleted**. However if it is required to alter the defined shape by actions such as moving surface points or adding extra sections, a **Primitive** must first be converted to a **Power Surface**.

All **Primitives** are created in the direction of the active **Principal Axis** (By default this is along the Z-Axis).

Basic Primitive Example

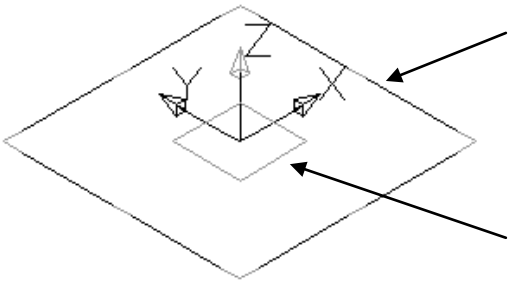
- Select **Create New Model.**
- Select the **Surface menu** icon from the **Main Toolbar**.
- Move the mouse over the **Surface Primitives** fly-out commands.

This menu allows the user to create a range of surface primitives. They are, from left to right, **Plane**, **Block**, **Cylinder**, **Cone**, **Sphere** and **Torus**.

- Select **Plane Primitive**.

A moveable **Primitive Surface** - **Plane** is attached to the cursor, with the centre of the **Plane** being it's local origin. This can be positioned by locking onto an item using the **intelligent cursor** or by typing in **X Y Z** co-ordinate value in the **Command Input** window.

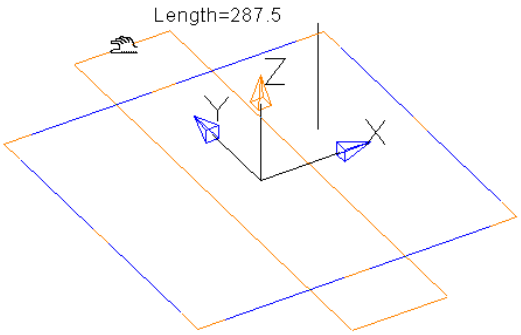
- Enter **0** in the **Command input box** and **press Return**.
- Select the **view Iso1.**



The selected **Plane** is shown is positioned with an inherent workplane attached to it. The orientation of the **Primitive Plane** can be changed dynamically by selecting and dragging on workplane attributes.

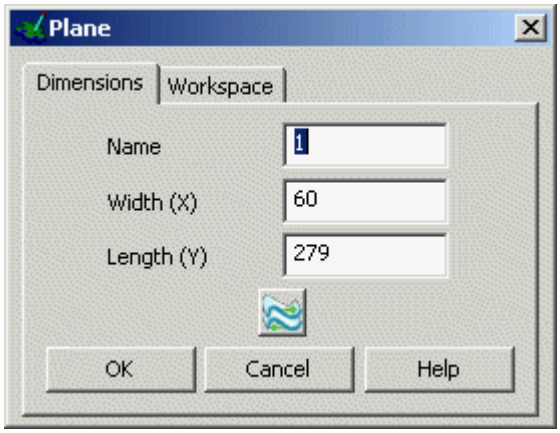
The sides of the actual **Plane** can be dynamically dragged to a different size.

- Select the **blue edge** at the **top** of the **square** and **dynamically pull** it out wards until a **value** of **280** is displayed and **release** the **mouse button.**



The width can also be modified at this point using the same method.

- Select the **blue edge** at the side of the square and **dynamically pull** it outwards to **100**.
- **Double click** on the **Plane** to open it's editing form.



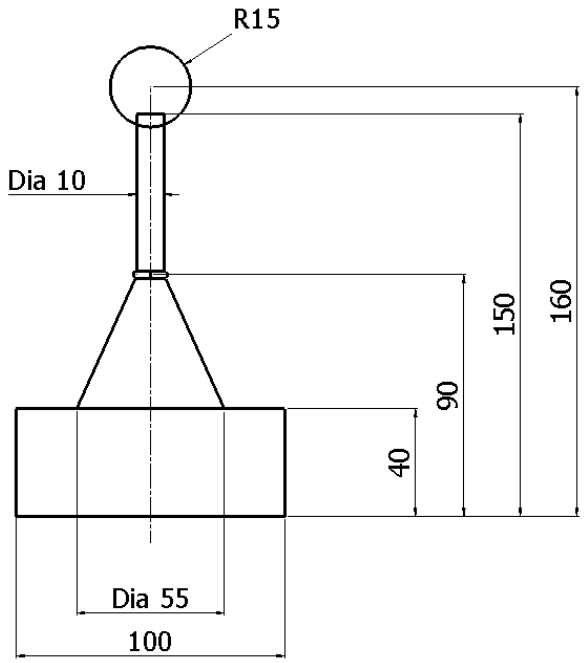
This form has two tabs and allows the user to rename or reverse the surface, input different values for width and length, re-orientate directly along a major Axis, or by applying a twist about a major Axis to change the angle.

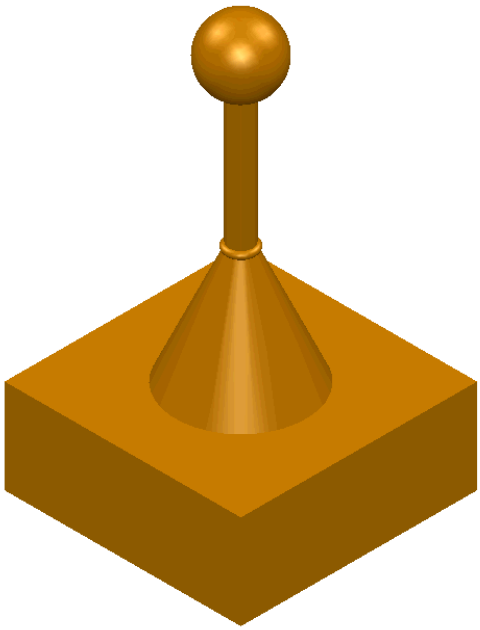
- **Change** the ***Length (Y)*** to **100**.
- Select the Workspace tab and change the ***define* Z position** to **40** before selecting **OK**.
- Press **Select** to exit **Primitive Plane** creation mode.

This **Plane** will be used as part of the next example, so do not delete it.

Simple Gear Shift design using Primitives

In the following example each of the six **Primitive Surface** options will be applied to the construction of a basic Gear Shift design.





- Click the **Workplane** icon and the option **Single Workplane**.
- Enter **0** in the **Command Input** box and **press Return**.

This **Workplane** will provide a visual marker for the dimensional datum.

- From the **Surface** fly-out menu , select **Block Primitive**.
- Enter **0** in the **Command Input** box and **press Return.**
- **Drag** or **Edit** the **Block** dimensions to **X 100**, **Y 100** and **Z 40**.

- From the **Surface** fly-out menu , select **Cone Primitive**.
- Enter **0 0 40** in the **Command Input** box and **press Return**.
- **Drag** or **Edit** the **Top Radius** to **5, Base Radius** to **27.5** and the **Length** to be **50**.

- From the **Surface** fly-out menu , select **Cylinder Primitive**.
- Enter **0 0 90** in the **Command Input** box and **press Return**.
- **Drag** or **Edit** the **Radius** to **5** and the **Length** to **60**.

- From the **Surface** fly-out menu , select **Sphere Primitive**.
- Enter **0 0 160** in the **Command Input** box and **press Return**.
- **Drag** or **Edit** the **Radius** to **15**.

- From the **Surface** fly-out menu , select **Torus Primitive**.
- Enter **0 0 90** in the **Command Input** box and **press Return**.
- **Drag** or **Edit** the **Minor Radius** to **1.5** and the **Major Radius** to **6.5**.

- Press **Select** to exit **Primitive Plane** creation mode.
- In **File** - **Save** the model as **D:\users\training\Coursework\GearStick** and select **File** - **Close**.

Extrusion Surfaces

An **Extrusion Surface** uses the shape of a selected **wireframe** entity, and extrudes it as a surface, normal to the **wireframe's** planer base (default). If required, it is possible to change the settings in **Tools – Options – Objects -Surfaces** for the **extrusion surface** to generate along the active major Axis. If several items are selected for **extrusion** then a separate **surface** will be generated for each. To create as one **surface**, the **wireframes** must first be merged into a single entity, **composite curve**.

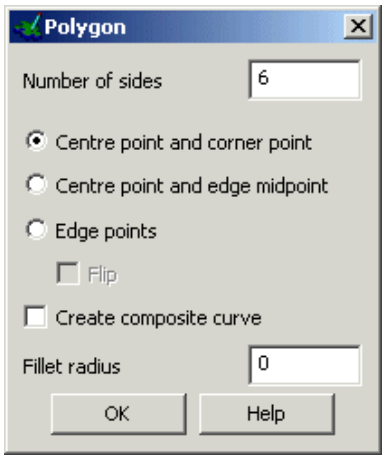
As with standard **Primitives** an **Extrusion Surface** can only have basic **parameters** modified unless it is irreversibly **converted** into a **Power surface** in which case a more comprehensive **editing toolbar** is available.

Extruded Polygon example

This example demonstrates the option to create a wireframe, **polygon** which in turn will be used to generate an octagonal **extrusion surface** with a side length of 50 and a height of 100.

- Select **Open New Model**.

- **Open** the **Line menu.**
- From the **menu** select **Polygon**.



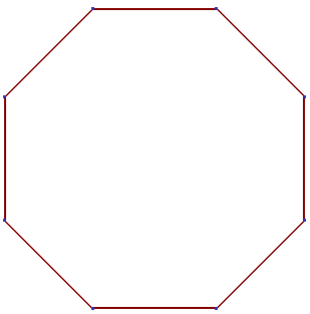
The polygon creation form is displayed. This allows you to specify the number of sides points to define a polygon that fits a circle around the outside.

The option to automatically generate a composite curve is useful as other commands, such as extrusion require a composite curve. If this option is switched off the polygon will be made up of single lines.

- Set the **Number of sides** to **8**.
- Select **Edge points** and **tick** - **Create composite curve**.

Start and end points of the first span need to be defined before dismissing the form.

- Enter **0** in the **Command Input** box and **press Return**.
- Enter **50** in the **Command Input** box and **press Return**.
- **OK** the **Polygon** creation form.



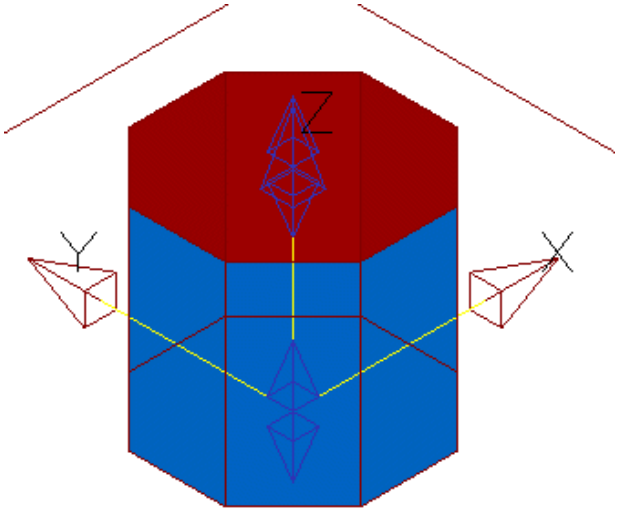
The **wirefame** is completed and is already a single closed **composite curve**.

This will be used as the shape of the **Extrusion Surface**.

- Select the **view Iso1**.

- Select the **composite curve**.

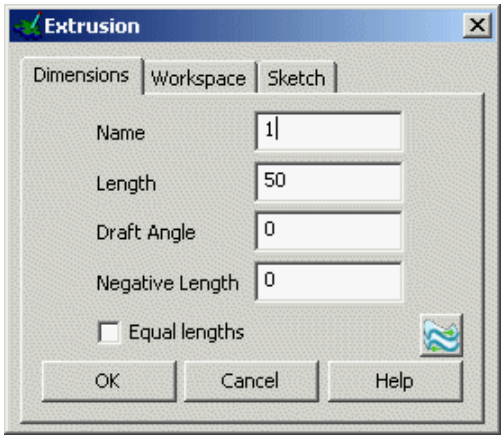
- Select the **Surface** menu and select **Extrusion**.



This produces an **extrusion surface** from the selected composite curve up the **Z-axis** by a default value.

The **extrusion** has two sets of Double Arrows which are used to dynamically change the length up or down the Z axis and if required to create a negative extrusion (lower set).

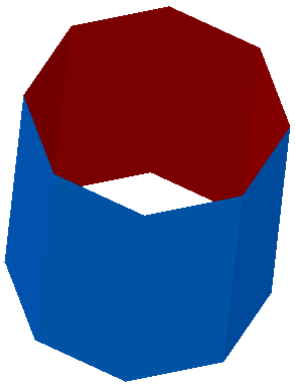
- **With** the **Left mouse button** select the **upper** set of **double arrows**.
- **Drag** the **extrusion upwards** to a **length of 50**.
- **Double-click** on the **surface edge**.



The **Primitive Extrusion** editing form will open providing the option to input settings and dimensional values. The **Extrusion** can be given a positive or negative draft angle. The **Keep** option will restore the original wireframe used to generate the extrusion.

The **extrusion** can be repositioned by entering new origin coordinates, and aligned to, or rotated about an Axis.

- **Enter** a **length** of **100** and press **OK**.
- **De-select** the **surface** by clicking away from the surface.



The **Extrusion Surface** is completed.

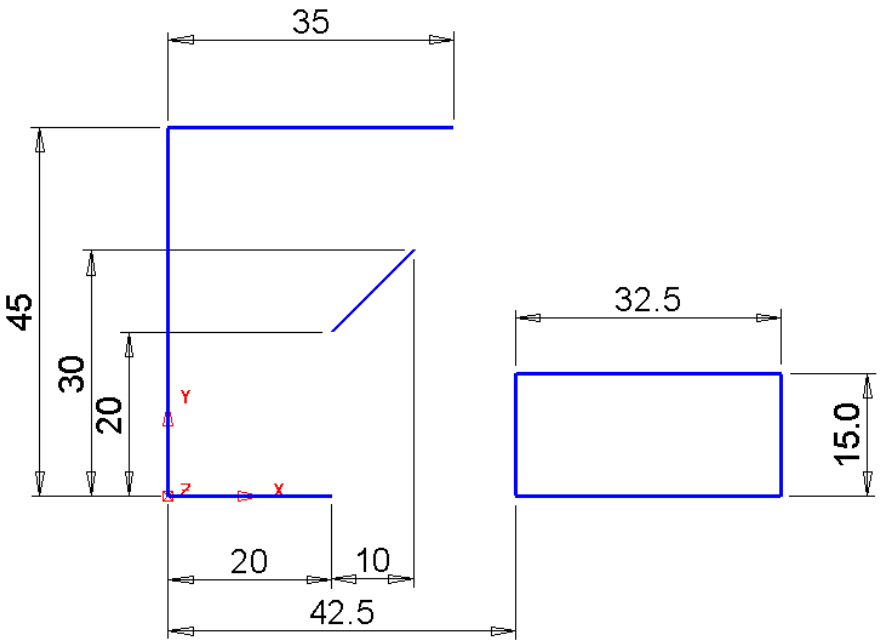
PowerMILL Modelling can also simultaneously extrude several, separate selected geometry items to make individual surfaces.

- **Select** the extruded **Surface**.
- From the **Right Mouse button menu**, select **Delete** (or Delete on keyboard).

The **Surface** has now been **deleted** and the original **composite curve** does not exist either. This was deleted earlier by default when the **extrusion** was created. To automatically retain future **curves** ***tick*** the box accessed from the pulldown menu **Tools - Options – Objects – Surfaces – Keep wireframe (extrusions and revolutions)**.

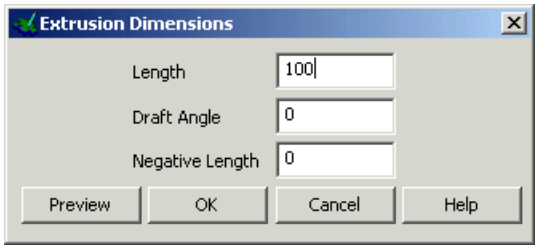
Extrusion Example 2

- Select the **Workplane menu**
- From the **Workplane menu** select **Single Workplane**.
- Enter **0** in the **Command input box** and **press Return**.
- **Generate** the following **8 lines** around the new **Workplane**.



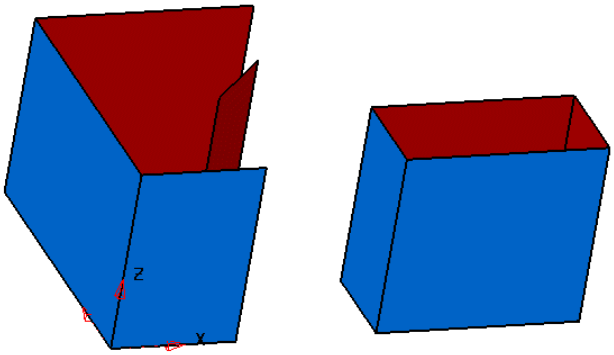
Each of the selected **wireframe** entities will create a separate **Extrusion Surface**.

- **Box select all** the **wireframe**.
- Select the **Surface** icon and select **Extrusion**.



For multiple wireframe selection a different form appears which requires a common input for **Length**, **Draft Angle**, and **Negative Length** for of all the **Extrusion Surfaces** being generated.

- Enter a **length** of **70** and press **OK**.
- **De-select** the surfaces.
- From the **Shading menu**, **select Shaded Wire View**.



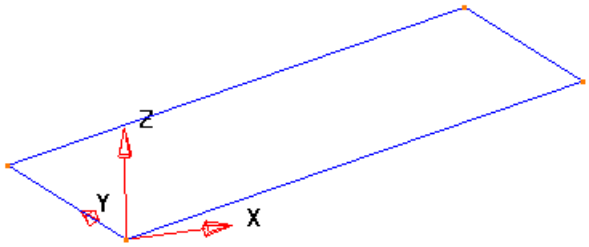
PowerMILL Modelling has created 3 separate **surfaces**.

Note: once created the **Extrusion Surfaces** can be edited individually.

- **Select all** of the **surfaces** and **select Delete**.

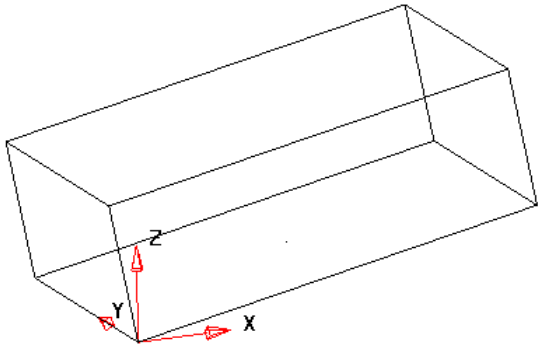
A 3D wireframe can be used to create an **Extrusion Surface**, by default it will generate along the **normal to the planar base** of the selected **wireframe**. Sometimes it would be more desirable to **extrude** along one of the major axes.

- **From** the **Line menu** select **Continuous Lines.**
- **Enter 0** and **press Return.**
- Enter **50 0 10** and **press Return**.
- Enter **0 30** and **press Return.**
- Enter -**50 0 -10** and **press Return**.
- **Click** on the **workplane** to close the shape.
- **Create** a **composite curve** (**Alt + left mouse button**).



The composite curve is angled to highlight the difference between planar and along an axis.

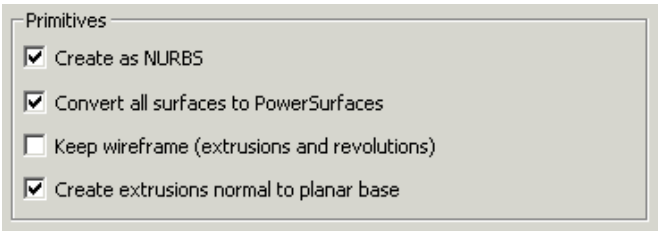
- **Select** the **composite curve**.
- From the **Surface** menu and the option **Extrusion.**



It can be seen that the surface has been extruded along the normal to the planar base of the wireframe.

This only happens if the wireframe is truly flat. If the wireframe is not flat then the extrusion will take place along the selected axis relative to the active workplane.

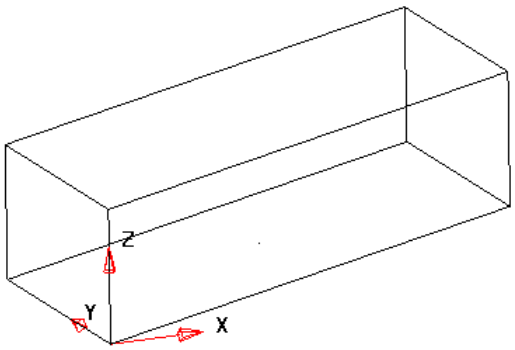
- Select **Undo** to get back to the stage prior to creating the **Extrusion Surface**.
- Select **Tools ➔ Options - Objects** – **Surfaces**.



The section Primitives controls the standard behaviour as they are generated.

The default option is for **Create extrusions normal to planar base** to be ticked.

- **Untick - Create extrusions normal to planar base** and press **Accept**
- **Select** the **Z Axis** and **select** the **composite curve**.
- From the **Surface** menu and the option **Extrusion.**



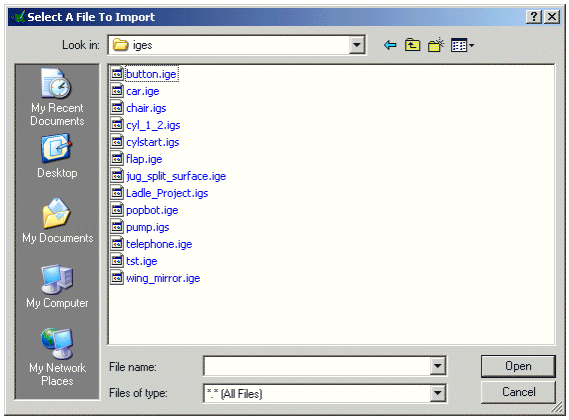
The **Extrusion Surface** will now be generated along the active **Principle Axis Z**

- **Select File ➔Close** but do not **Save** the model.

Pump Project Example

In this example an IGES file containing wireframe data is Imported into PowerMILL Modelling and the Surface Model will be created in stages to compliment the remaining chapters. Many different types of data formats can be imported into PowerMILL Modelling depending on the customer having purchased the relevant translators. Data translations can also be carried out on the Internet on a pay as you go basis through our Technical Support.

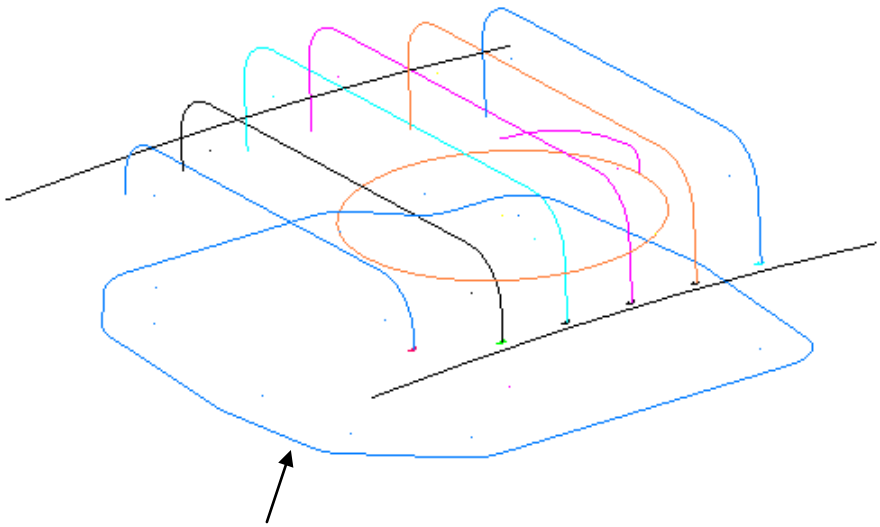
- **Select Open New Model**.
- Select **Import Data File**. .



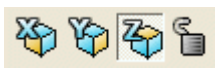
The import form appears to search for the required file.

- From **D:\Users\Training\PowerMILL Modelling_data\iges** select **pump.igs** and press **Open**.

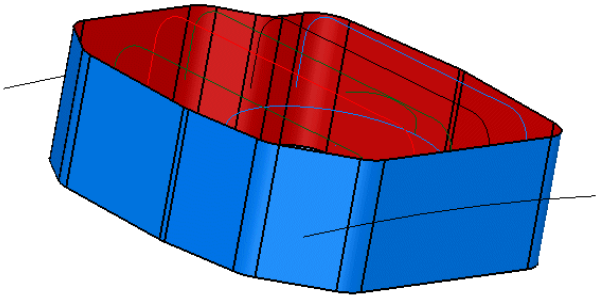
The multi-coloured wireframe appears.



- **Select all** of the **wireframe** that defines the base.

- **Select** the **Z- axis**. 

- Select the **Surface** menu and select **Extrusion**.
- Drag the **extrusion length** to **40**.
- Press **Select**.



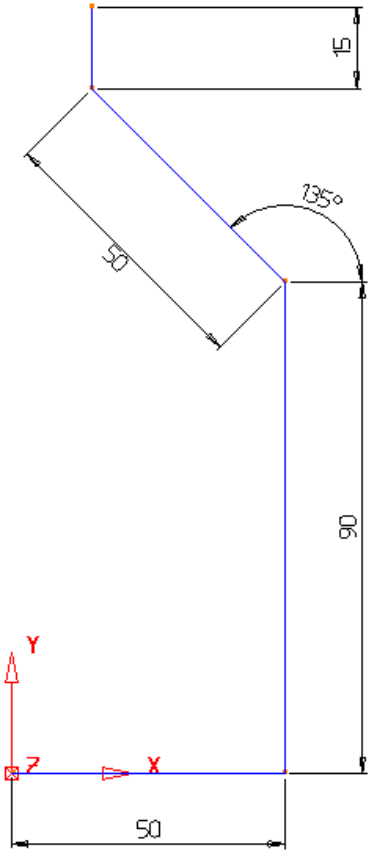
The **extrusion surface** is complete. The model must now be **Saved** ready for the next stage.

- Select **File ➔ Save As** and enter the name **pump-project2** and press **Save** (Work will continue on this **model** during later chapters).
- Select **File ➔ Close**.

Surfaces of Revolution Example

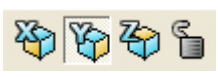
A surface of revolution is creating by revolving single geometry or a composite curve around a specified principal plane.

- **Select Open New Model**.
- Create a **Workplane** at **0** and create the bottle section geometry.

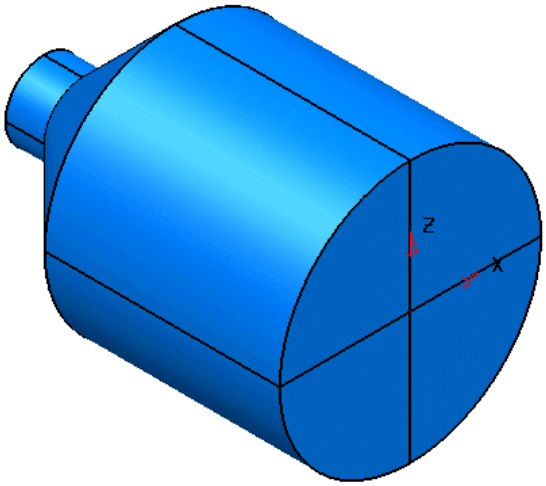


This shape will be connected together with a composite curve.

This curve will be revolved by 360 degrees around the workplane generating a surface. The correct axis for rotation around must be pre selected.

- Select the **Y-Axis**. 

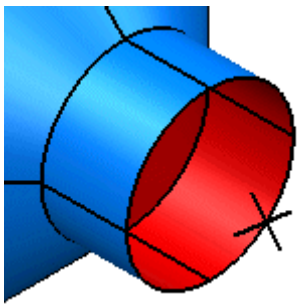
- Create a **composite curve** of the section geometry.
- **Select** the **wireframe** and select the **Surface** menu.
- Select **Surface of Revolution**.



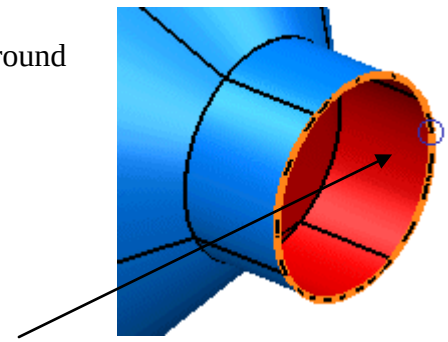
The selected composite curve is spun around the active axis (Y) producing the surface of revolution producing the bottle shape. If a lid was required on the open end of the bottle, this can be made by capturing the end curve and using the Fill in surface command.

To capture the end curve a composite curve is traced.

- **Select** the **view Iso3**.
- **Select** the **Curve** menu then **Create** a **Composite Curve**
- **Click** on the **top part** of the bottle.



A composite curve can trace all around the curves of a surface in both directions.

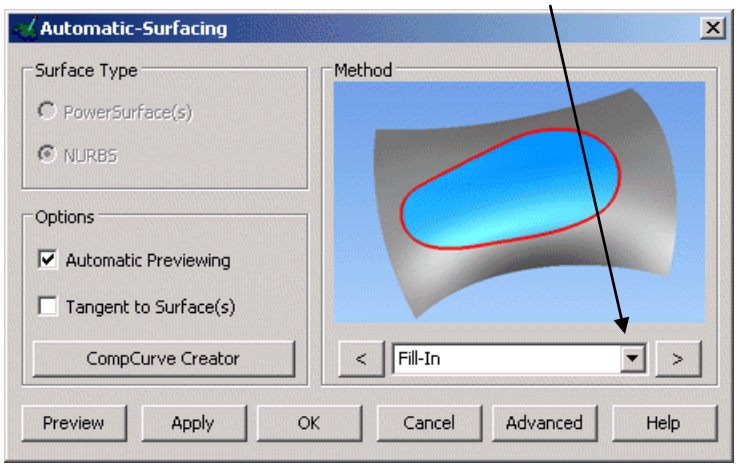


- **Trace around** the **top** of the bottle until closed.
- **Select Save** and **Eject** on the composite curve menu.
- **Select** the **Composite Curve**.

A fill-in surface is a surface that is generated from a composite curves or a series of wireframe. It is useful for filling in gaps in models.

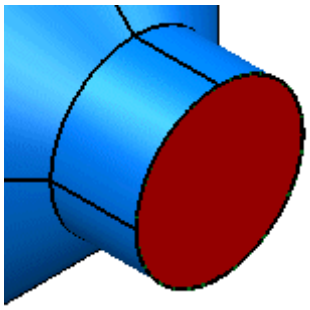
- From the **Surface menu** select **the Automatic-Surfacing Wizard**

- Use the pull down to select **Fill In** (if not already picked).



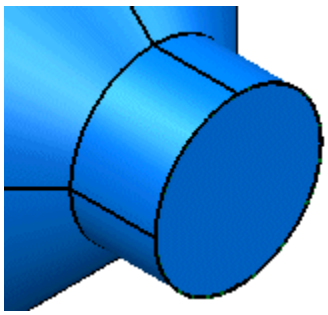
This wizard will be used later on in the course.

- Press **Apply** and then **OK.**



The surface has been generated. The surface is shown in red as the inside is facing towards us. This can be changed by reversing the surface.

- **Select** the **surface** with the **Left mouse button.**
- From the **Right mouse menu** select **Reverse.**



The surface has been reversed, showing the blue side, which is the outside.

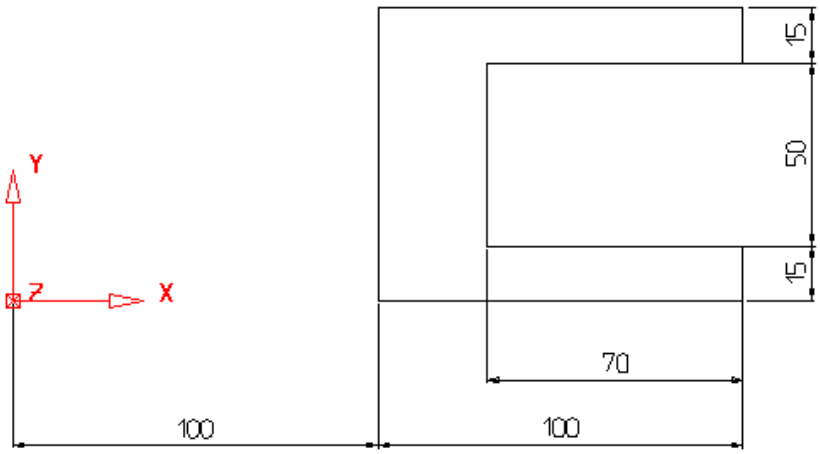
- Select **File ➔ Save As** and save the file as: **D:\users\training\Coursework\my-parameters .**

When saving, PowerMILL Modelling stores the model in this state. It also overwrites the ability to go back any further as a new marker has been set to allow the user to undo back to this stage.

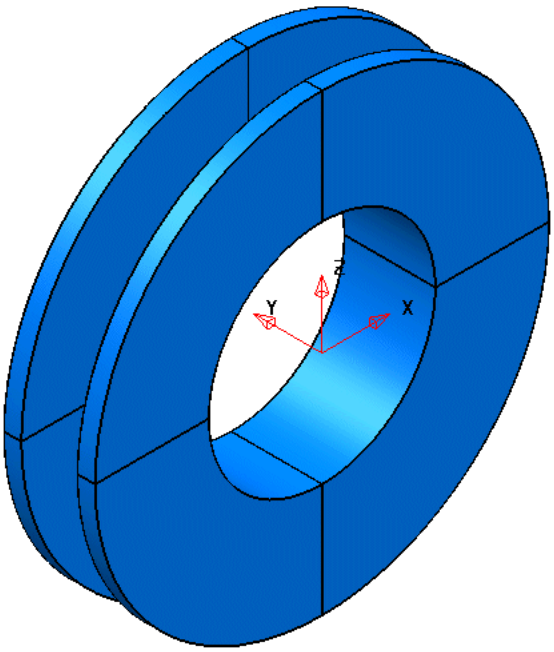
Wheel Example

Create the following wheel shape. This will then be altered using various commands.

- **Select** the **view from top**.
- **Select** and **Delete** the **two surfaces.**
- **Generate** the basic wireframe **shape**.



- **Select all** the **wireframe.**
- **Select** the **view Iso1** and select the **Y plane.**

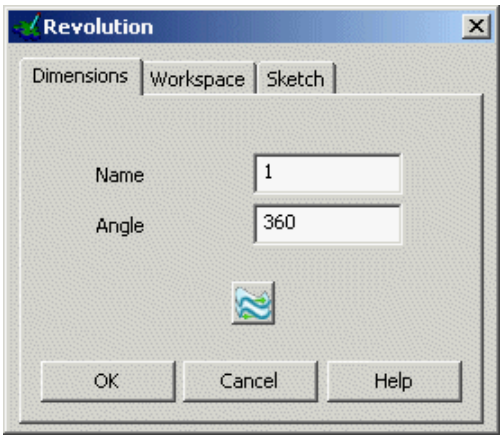


- From the **Surface menu**

  select **Surface of Revolution.**

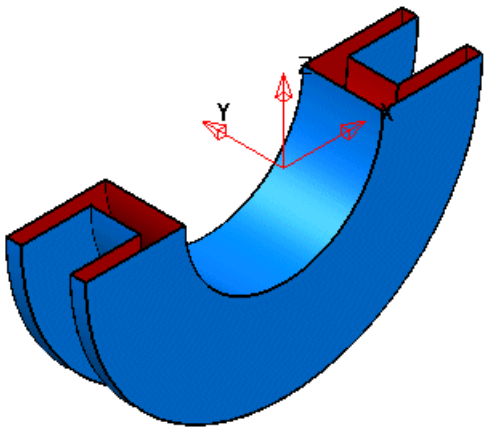
The surface of revolution is generated. The only option available to edit this surface by parameter is to change the number of degrees it spins around from the default of 360 degrees.

- **Double click** the **surface** with the **left mouse button**.



The primitive revolution form appears, showing the workplane options as well as the Angle.

- **Change** the **Angle** to **180** and press **OK**.

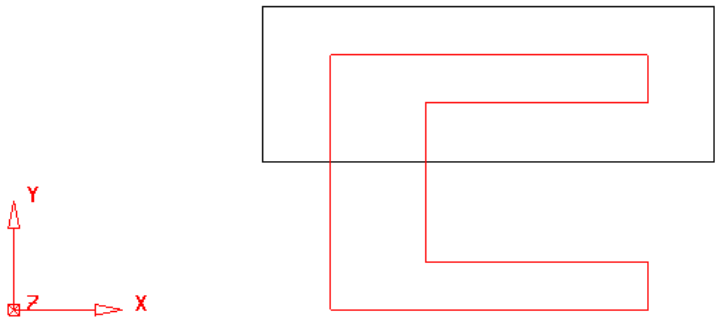


The surface had been generated through an angle of 180 degrees.

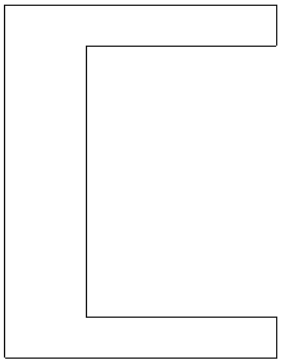
To alter the physical shape of the surface of revolution the original wireframe has to be altered.

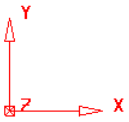
One way to alter the wireframe is to use the stretch command from the Edit toolbar.

- Click on **Undo** **twice** to return back to the original wireframe.
- Select **Edit toolbar** and open the **Move/Copy menu.**
- Select **stretch object.**
- Select the **top half** of the shape, by **dragging** a box over it as shown.



- Enter **0 50** which will only move the selected parts 50mm in the Y, stretching the back and inner wall.

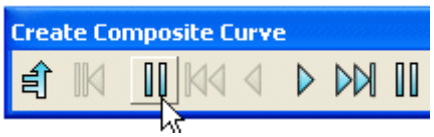




The top half is dragged upwards and the connecting geometry is stretched.

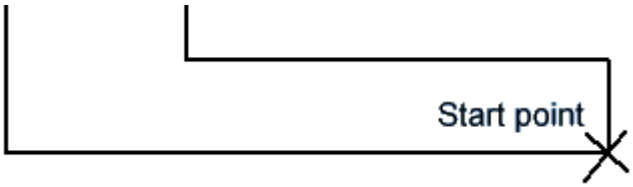
A new surface of revolution can be made of only the inner feature by limiting the initial composite curve using the start and stop feature when tracing.

- **Select** the **Curve** menu and select **Composite Curve.**
- **Select start point** from the toolbar.

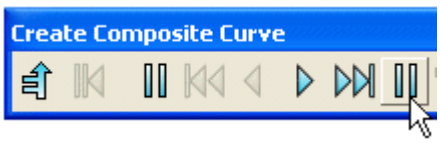


The cursor changes into two vertical bars like the Define start point icon. A circle will mark the selected start point.

- **Snap** this to the **bottom right corner end** of the wireframe.

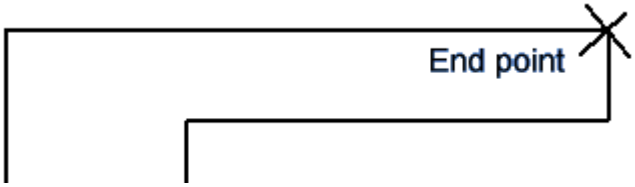


- **Select end point.**



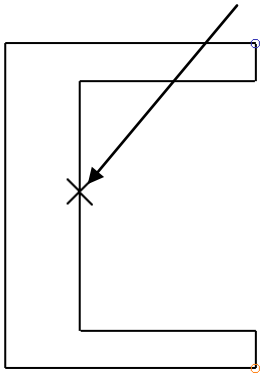
The cursor changes into two vertical bars, like the Define End point icon.
A circle will marks the selected end point.

- **Snap** this to the **top right corner end** of the model for the end point of the composite curve as shown.



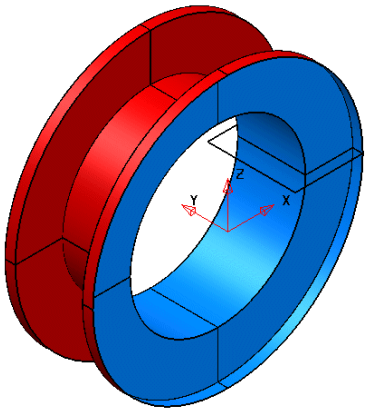
There are two options for the composite curve to be. To select the path, one of the wireframe lines is selected.

- Select the **inner vertical line**.



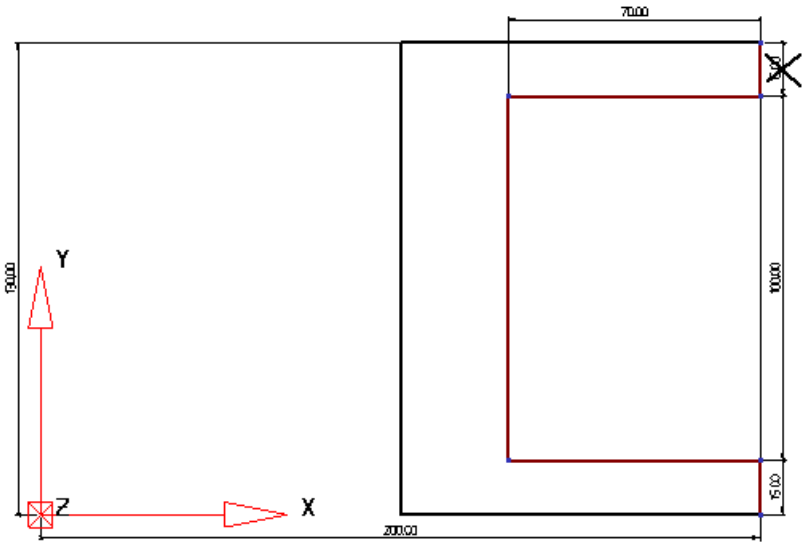
There are two options to create a composite curve in this shape. By selecting the inner geometry a composite curve is traced between the two circles.

- **Select Save** and **Eject** on the **composite curve toolbar.**
- **Select** the **Composite Curve.**
- From the **Surface menu** select **Surface of Revolution.**



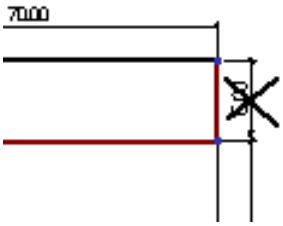
The outer surface is produced. This surface can be changed by using the Edit facility from the primitive revolution form.

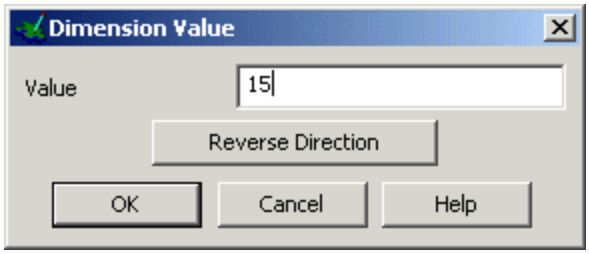
- **Double click** the **surface** to bring up the primitive revolution form.
- From the **Sketch tab**, select **Edit Sketch**.
- From the **Surface/Curve editing toolbar**, select **Edit curve using active dimensions. (pull down from edit curve in 3D)**



PowerMILL Modelling undraws the surface and creates dimensions for the wireframe. These dimensions can be double clicked and changed.

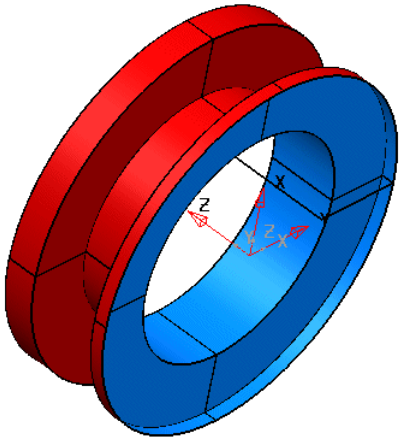
- **Double Click** on the text **15** dimension.





The dimension value form appears.

- **Modify** the **value** to be **35** and press **OK**.
- Double click the **100** dimension; change the value to **80** and **OK**.
- Select the **Finish** button and **OK** the form.

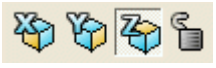


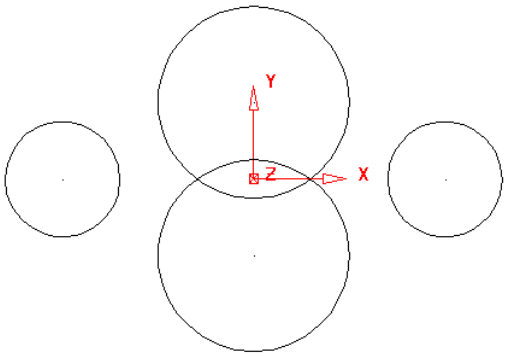
The surface is modified to suit the wireframe changes.

- **Select File ➔ Save** and then **File ➔ Close.**

Bottle Exercise

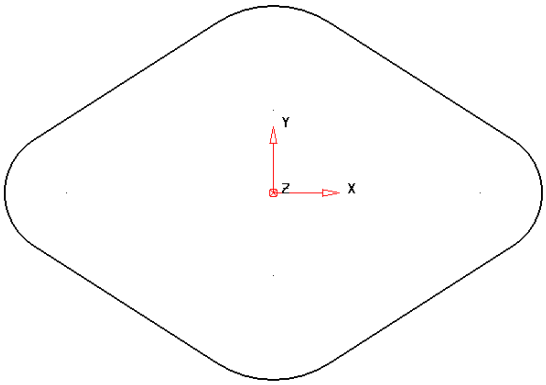
Using arcs, generate a bottle shape starting with the base.

- **Select Create New Model.**
- **Select** the **Z-axis**  and **Create** a **Workplane** at **0.**
- **Generate two circles** of **radius 15** at **50 0** and **-50 0.**
- **Generate two circles** of **radius 25** at **0 20** and **0 -20**.

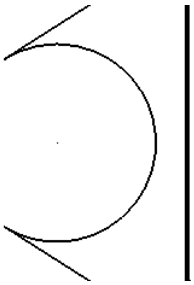


Tangent lines will join and trim these circles together.

- Select the **Line** option and select the **single line mode.**
- **Move** the mouse over each circle until it says **'Tangent'** and click to form the tangent lines.

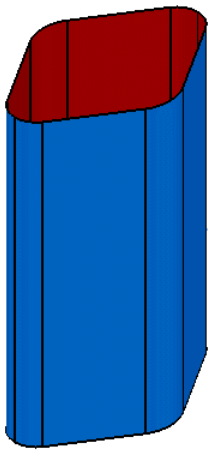


The base of the bottle is complete and can now be extruded.



Note: If the arc trimming does not appear in the correct place as shown. Select the arc and grab hold of an end circle and drag it around to the end of the line.

- **Select all** of the **wireframe.**
- Select the **Surface** menu and select **Extrusion.**
- **Modify** the **length** to **200mm.**

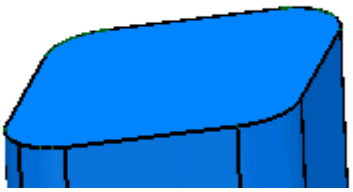


The sidewalls of this bottle have now been generated.

The next stage is the creation of fill-in surfaces across the top and base of the bottle form.

A quick way to generate composite curves that are flat on a plane is to hold down the Alt key and click the geometry with the left mouse button.

- **Hold down Alt** and **left mouse click** on the **top edge.**
- **Hold down Alt** and **left mouse click** on the **bottom edge.**
- **Select** the **top composite curve**.
- From the **Surface menu** select the **Surface Wizard.**
- **Create** a **Fill in Surface** as before.
- **Repeat** for the **bottom edge** of the bottle.

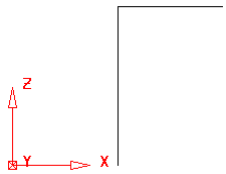


The top and bottom surface have been created. To make the wireframe for the bottle top easier to create a new workplane is generated.

- Select the **top surface** and select **Create Workplane at top.**
- Select the **Y plane.**
- Select a **view down** the **Y axis.**

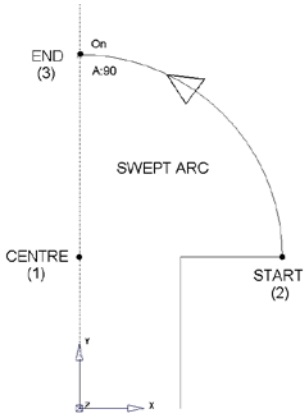
Select all of the **surfaces** and select **Blank (Ctrl + J).**

- **Create** a **continuous line** from **10** to **0 0 15** and then to **10.**

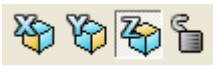


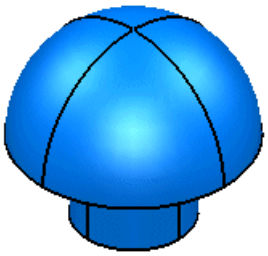
An arc will be created from the end of the line around an arc of 90 degrees to form the bottle top.

- From the Arc Menu select **Arc through Centre.**
- Enter a position of **0 0 15** and **snap** onto the **start position.**

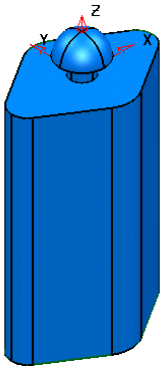


Arcs can be modified dynamically by moving the ends around the centre with the left mouse key.

- **Drag** a **span** of **90** degrees.
- **Select all** of the **wireframe** and select the **Z plane.** 
- From the **Surface menu** select **Surface of Revolution.**



The bottle top surface is generated. The blanked items can be displayed by using unblank.

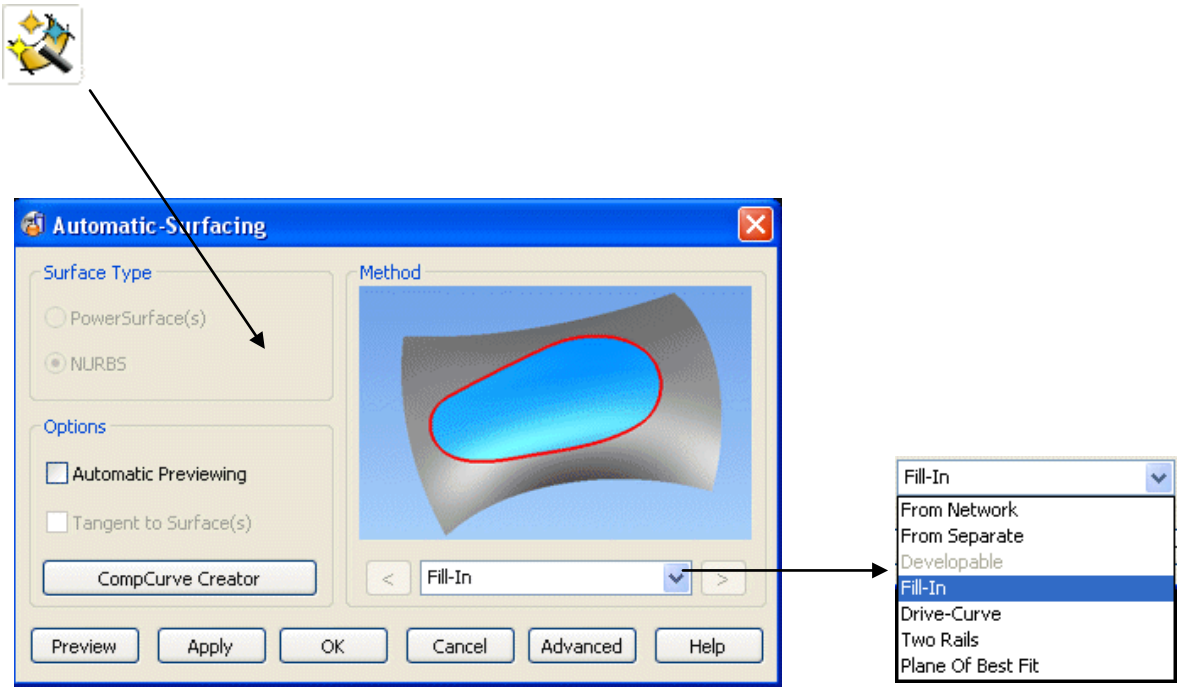


- Select **Ctrl + L** (unblank).
- **Select File ➔ Save As.** Browse to the directory **D:\users\training\Coursework** and save the model as **my-bottle.**
- **Select File ➔ Close.**

6. Automatic Surfacing Wizard

Introduction

Several of the **PowerSHAPE surface** creation options have been included into an easy to apply, **Automatic Surfacing Wizard**. If the user selects **wireframe** before opening the wizard then the most likely surfacing method is selected ready to be previewed and/or applied. If an alternative, valid surfacing method is required then the user can toggle to it by opening the list of options and clicking on the downward pointing chevron.



Automatic Surfacing options covered as training examples in order of appearance are:-

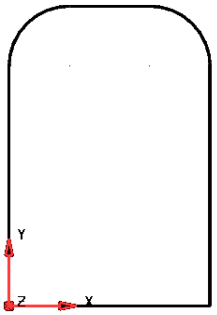
Fill-In
From-Network
Drive-Curve
From Separate
Two Rails

Fill-In *Surface*

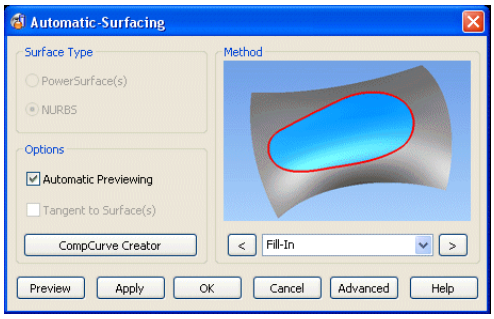
A **Fill-in surface** is usually created from one or more enclosed **wireframes**. It can also be created from open ended, **wireframes** as well as **Point** data.

Example

- Create a ***wireframe***, **Rectangle of lines** from the **0** ***datum*** with sides of **X50** and **Y75**.
- Create **R 15 fillets** at both of the top corners.

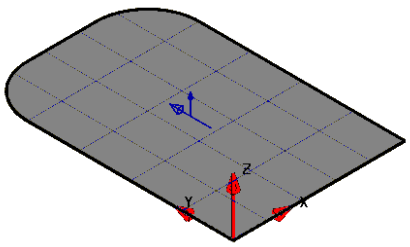


- Select all the **wireframe** entities.
- From the **main** toolbar select the **Surface** icon.
- In the ***left hand*** toolbar select the **Automatic Surfacing** option.



The most obvious option for the selected ***wireframes***, **Fill-in** will appear in the form.

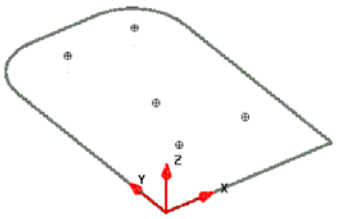
- Check that **Fill-In** is the selected **surface** creation option and **Apply**.



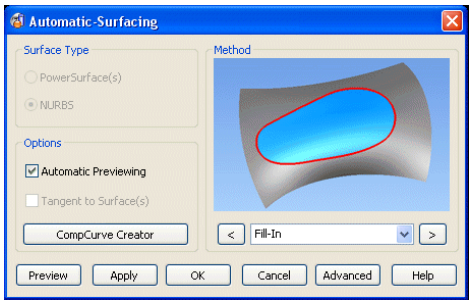
A Fill-In surface will is patched inside the enclosed **wireframe**.

- Select and **Delete** the **Fill-in Surface**.
- From the **Main** toolbar select the **Workplane** options.
- From the **workplane** toolbar select the **Create a point** option.
- In the **command input** box enter the following 5 co-ordinate positions pressing the **Return** key after each one to accept:-

25	**37.5**	**0**
15	**15**	**5**
15	**60**	**5**
35	**60**	**5**
35	**15**	**5**

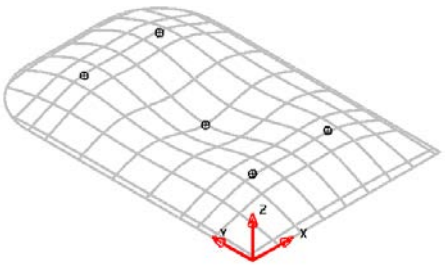


- Select all of the **wireframe** including the 5 **points**.
- From the **main** toolbar select the **Surface** icon.
- In the ***left hand*** toolbar select the **Automatic Surfacing** option.



The most obvious option for the selected ***wireframes***, **Fill-in** will appear in the form.

- Check that **Fill-In** is the selected **surface** creation option and **Apply**.

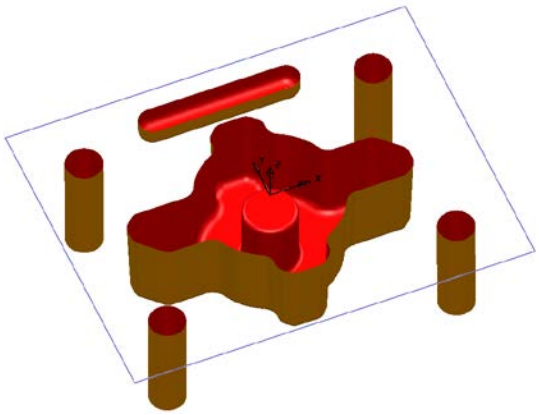


The **Fill-in surface** has blended through the selected **point** data as well as the outside wireframe.

Die Example

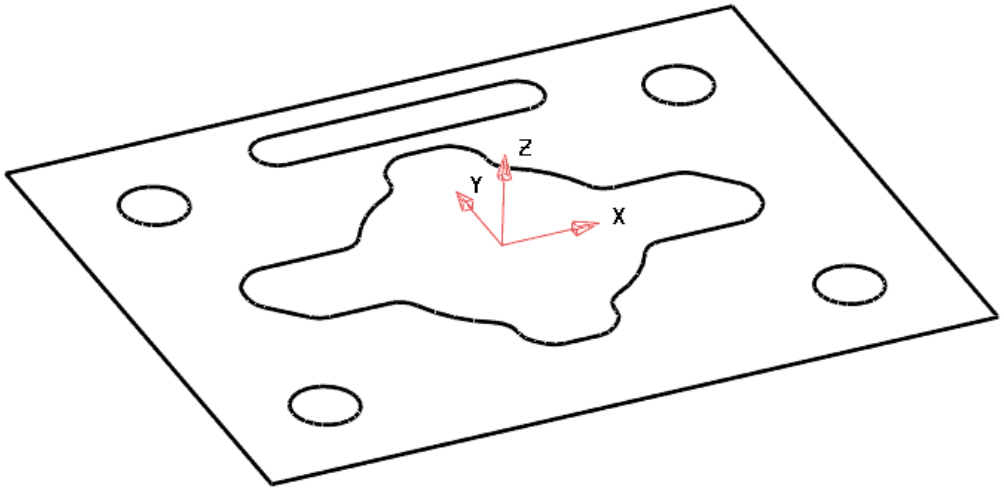
A **Fill in surface** can also be made up from several **wireframes**. When a **Fill-in surface** is generated, the **composite curve** is used to create the visible trimmed area within a surface.

- **Close** the existing **model**.
- **Open** a ***New*** **model**.
- Select **File - Import** and locate the **wireframe** model:-
  …..\PowerSHAPE_Data\psmodels_n_dgk\Fill-in_Die.dgk

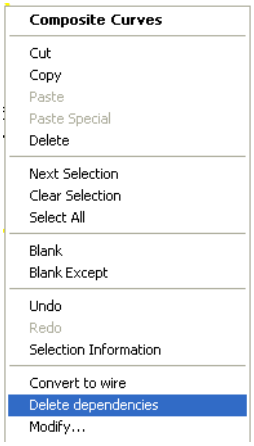


A new **Fill-in surface** will be generated inside the imported, rectangular **wireframe** and from **composite curves** traced around the top edges of the **surface** forms.

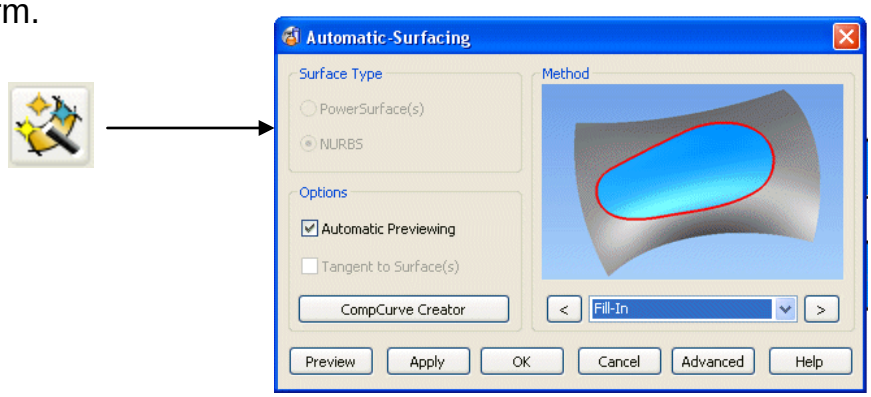
- With the **Alt** key held down, left mouse click the upper edge of each **surface** form to create a new **composite curve** for each one.



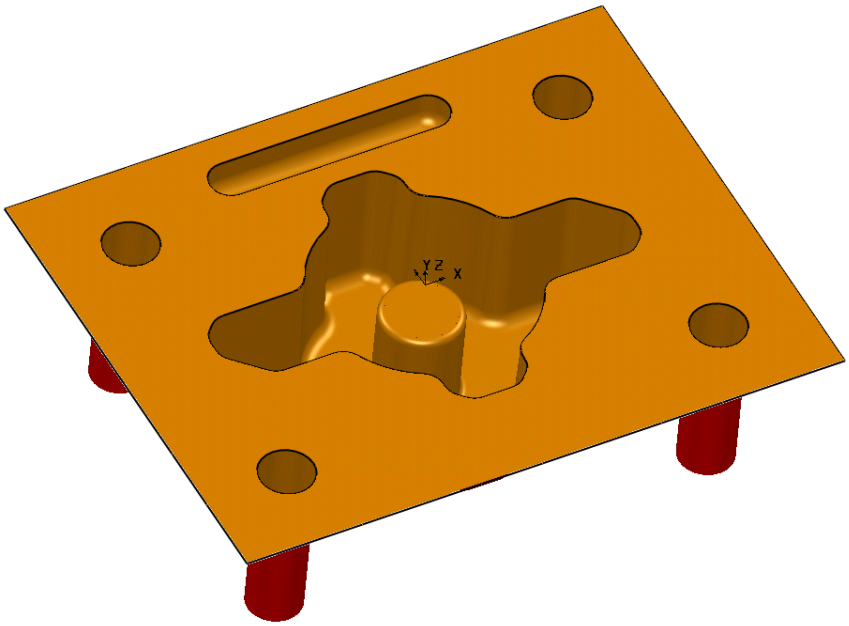
- Select all the **composite curves** and right mouse click on one to open the local menu.



- In the local menu select **Delete dependencies** (This will remove any tangencies inherited from **surface** edges along which **composite curves** have been traced).
- With all the **composite curves** selected, open the **Automatic Surfacing** form.



- Select **Fill-in** as the surfacing ***Method*** before selecting **Apply**.

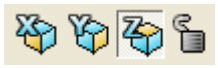


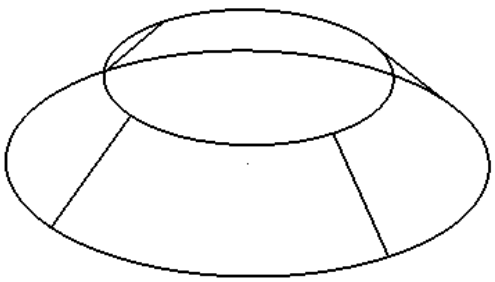
The trimmed upper surface appears as shown left.

- From the **main** pulldown menus select **File - Save As**, and store the ***psmodel*** as **…D:\users\training\Coursework\Fill_in_example2**
- From the **main** pulldown menus select **File ➔ Close**.

3D Fill-in Surface Example

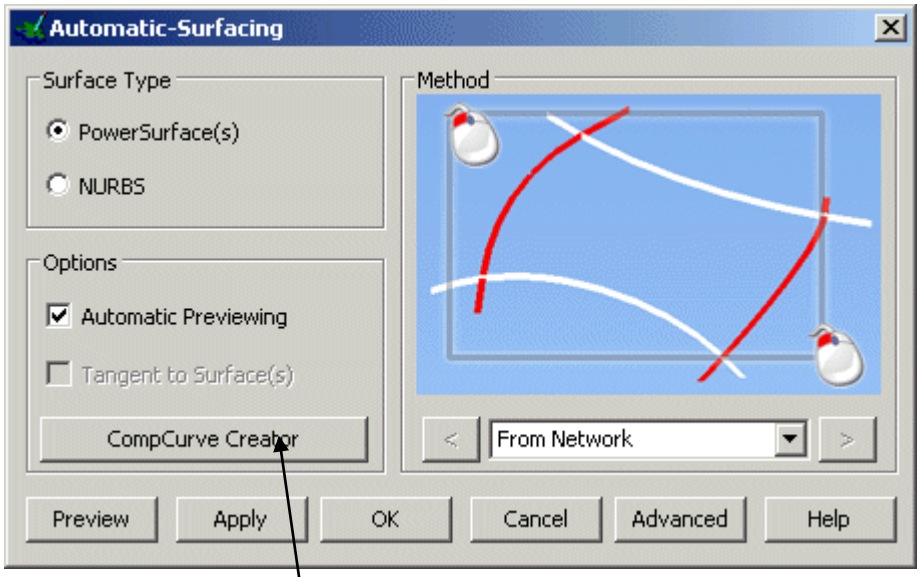
A **composite curve** does not have to be created in advance as it can be generated within the **Fill-in surface** form.

- Select **Create New Model**.
- **Create** a **single line** from **50** to **-20 0 20**.
- **Select** the **Z plane**. 
- **Select** the **line**. Select the **wireframe view**.
- From the **surface menu** select **Surface of Revolution**.



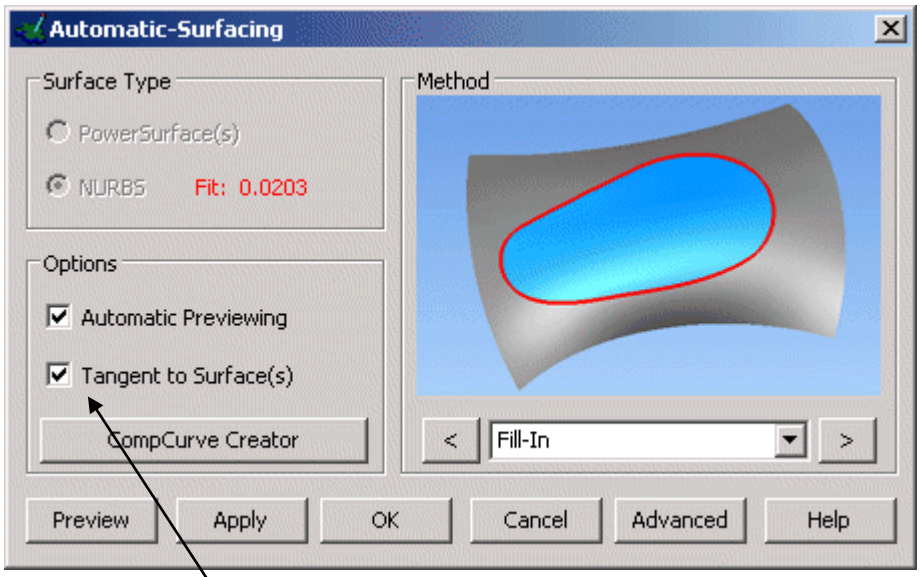
A conical **surface** has been created.

- Open the **Surface Wizard**.

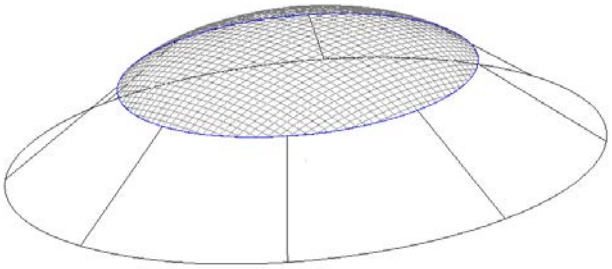


- Select the **CompCurve Creator** option and trace a **composite curve** around the ***top edge*** of the **surface**.
- Press **Save** and **Eject**.

Once the **Composite Curve** is completed the **Wizard** recognises that the **curve** is suitable for producing a **Fill-In** Surface. The **surface** creation form is updated and a preview of the surface is displayed. In this case the surface produced is flat but in many cases the user requires a new **surface** that is ***tangential*** to the surrounding **surfaces**.

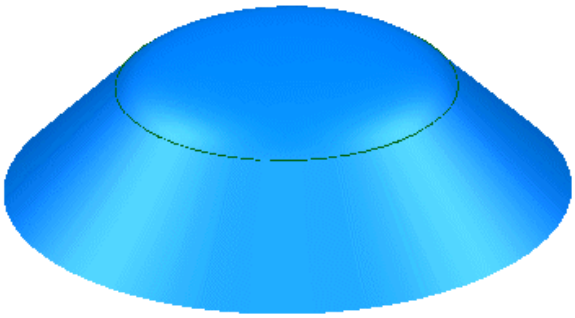


- Switch **Tangent to Surface(s)** on (ticked).



The surface previewed is tangential to the surrounding surface.

- **Apply** and **OK** the form.
- **Select OK** to the fill in surface form.
- Select the **Shaded view**.



The domed **Fill_in surface** appears as shown left.

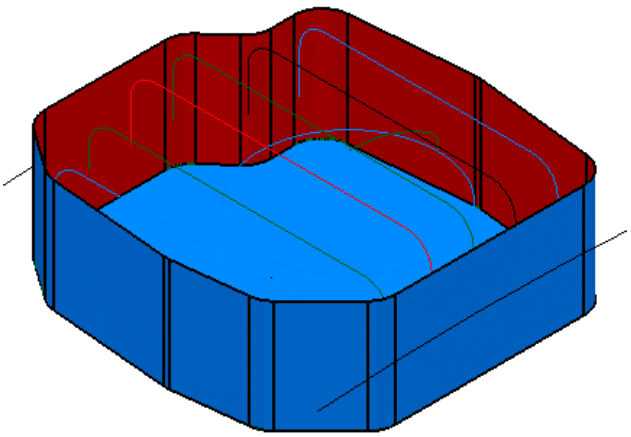
- **Select File ➔ Close**
- Select **No** in response to ***Do you wish to save the changes***….

Pump Project Example….continued.

Using the pump example a **Fill in Surface** will be used as a flat base for the extruded side.

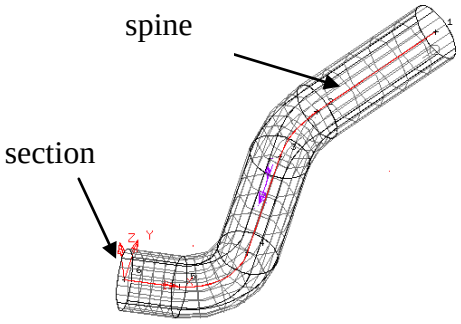
- **Open** the model **pump-project2**.
- Generate a **composite curve** around the **base** of the extrusion.
- Make a **Fill-in surface** from the selected **composite curve**.

.

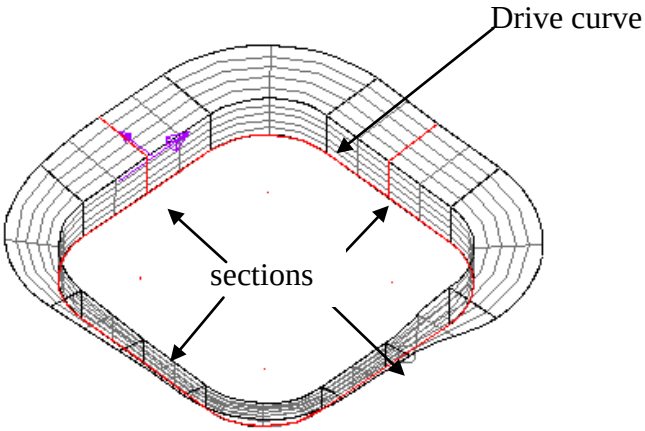


- **Select File➔ Save** and then **File ➔ Close**.

Drive-Curve *Surface*



A **Drive curve** can be defined as a spine running through a surface upon which the sections hang perpendicular. The illustration shows a single circular section being used along the whole drive curve.

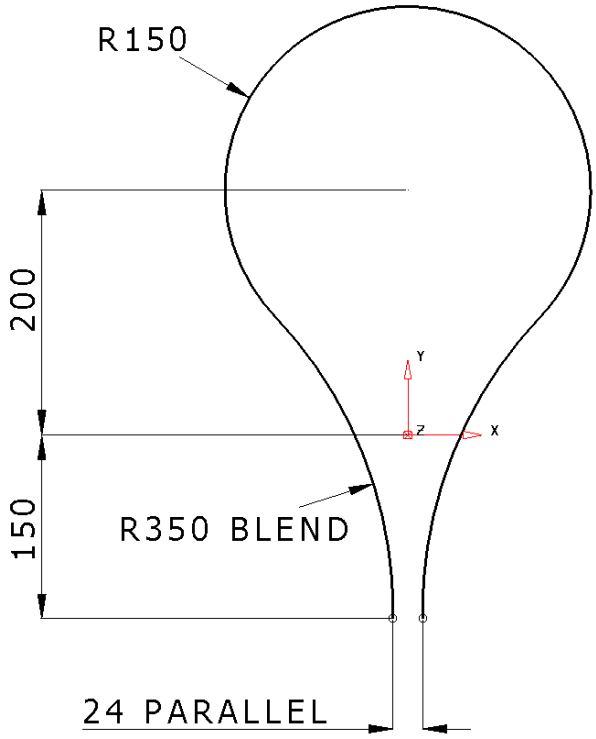


A single section or a variety of different size sections can be used along the drive curve to generate the surface. All sections must be either open or closed.

Racket Example

The first step is to create the wireframe for the drive curve of the tennis racket.

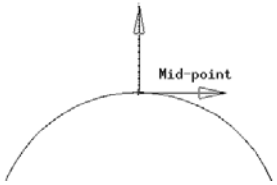
- Create a **workplane** at **0** and then construct the following wireframe.



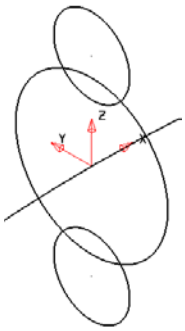
This shape will form the single **drive curve** along which the **surface** will be generated.

Wireframe sections will be defined, in this case, perpendicular to and at strategic positions along the drive curve.

- Create a **workplane** and position it at the **midpoint** at the top of the racket.

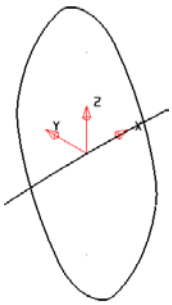


- **Zoom** into the area around the new **workplane**.
- Select the **X** principle **plane**.
- **Generate three circles**, circle 1 **radius 8** at **Z 0**, circles 2 and 3, **radius 4** at **0 0 10** and **0 0 –10**.



These will be filleted by an arc of radius 25. During this creation you may need to make another circle of radius 8, due to the automatic trimming.

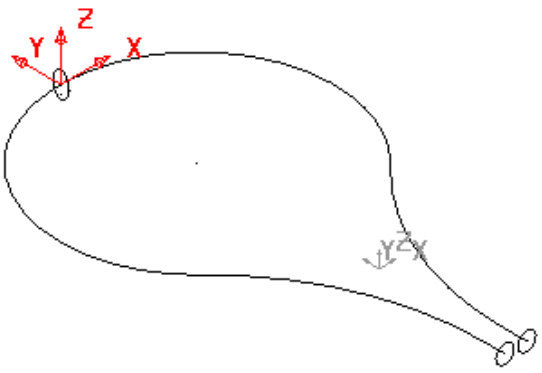
- **Fillet** the circles with an **arc** of **radius 25**.



This will be the main centre section of the racket.

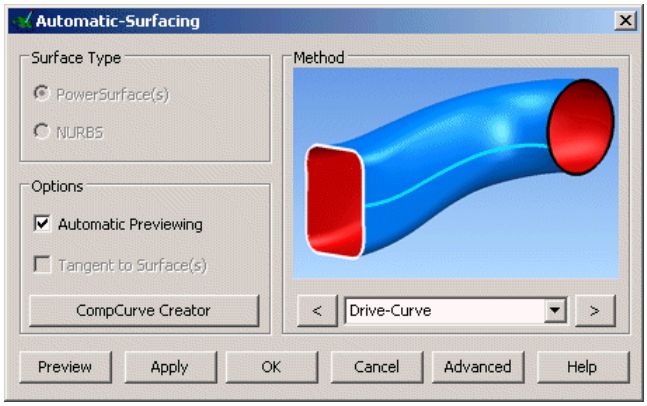
The other sections are circles and they can be placed directly at the grip end, without the need for another workplane.

- Select the **Y** principal **plane**.
- Generate **two circles of radius 10** with their **centres** snapped to the **end** of the lines.



The drive curve and each cross section have to be turned into composite curves before a drive curve surface can be produced.

- **Create** a **composite curve** for **each cross section** and the **drive curve.**
- **Select all three sections** and the **drive curve.**
- From the **surface menu** select the **surface wizard.**

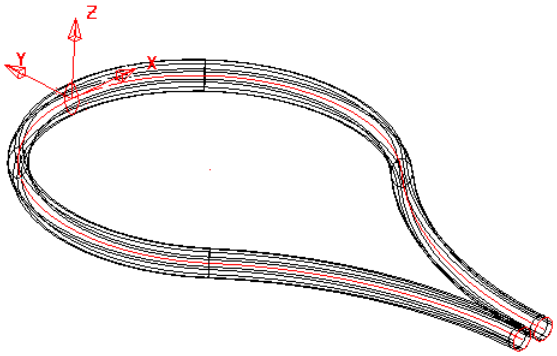


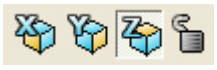
The surface wizard recognises that the wireframe selected is suitable for creating a drive curve surface and changes the pull down menu accordingly. A preview of the surface is also generated

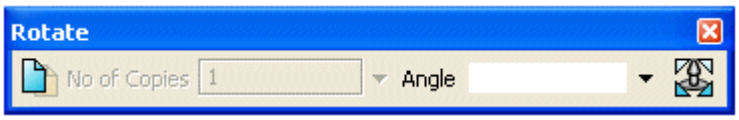
- Click **OK.**

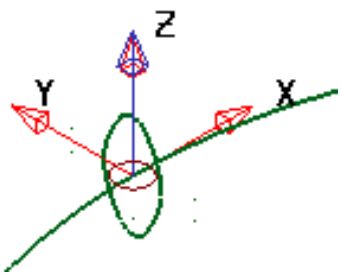
This generates a surface with a changing section from the first circle to the defined section and then back to the last circle.

To maintain a particular cross section at a position on the drive curve extra sections may be added.



- **Select** and **Delete <u>only</u>** the **surface**.
- Select the **composite curve** section at the top of the racket and select the **Z principal plane.** 
- From the **Edit Toolbar** select **Rotate object**.

This opens the rotation toolbar 

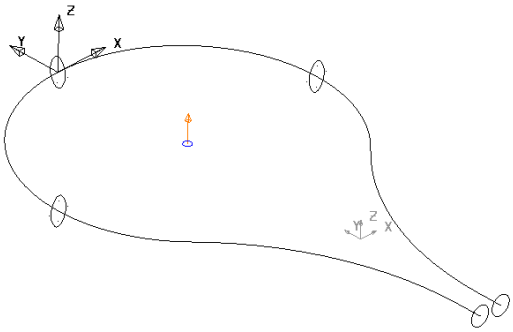


A circle and arrow is drawn around the centre of the selected object. This is the rotation centre and can be dragged to the required position.

Alternatively the option reposition the rotation option can be used which attached the arrow and circle to the cursor for positioning.

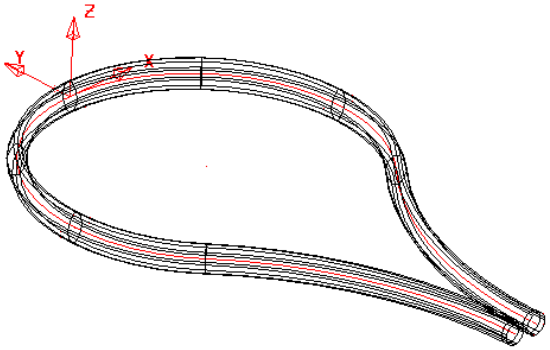
- Select **reposition rotation axis.**
- **Click** on the keypoint at the **centre** of the **racket.**
- Click the **copy button,** enter **No. Copies** as **1** and **Angle** as **90** and press **Return.**

- Leave **No. Copies** as **1** and **Angle** as **180** and **press Return.**



Between these three shaped cross sections the surface shape will remain the same.

- Press **Select** .
- Generate a **surface from drive curve** using all **five** sections.



You can also use just one section; one of the circles, placed anywhere along the drive curve to generate a surface.

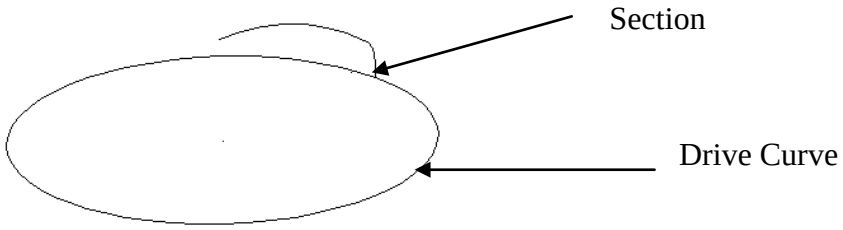
Note: If you have many composite curves to generate you can **select all** of the required **geometry** and select **Edit ➔Convert ➔ Wireframe to Composite Curve**.

- **Select File➔ Save As** …… **D:\Users\Coursework\my-racket.**
- **Select File ➔ Close**.

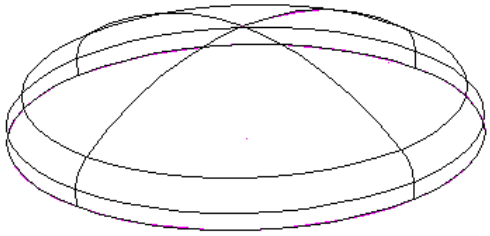
Pump Project Example….continued

Using the pump example we can use the round and arc geometry to make a dome surface.

- **Open** the **model pump-project2. Switch on all levels.**
- Select the **dome** geometry and use **Blank Except. (Ctrl + K).**

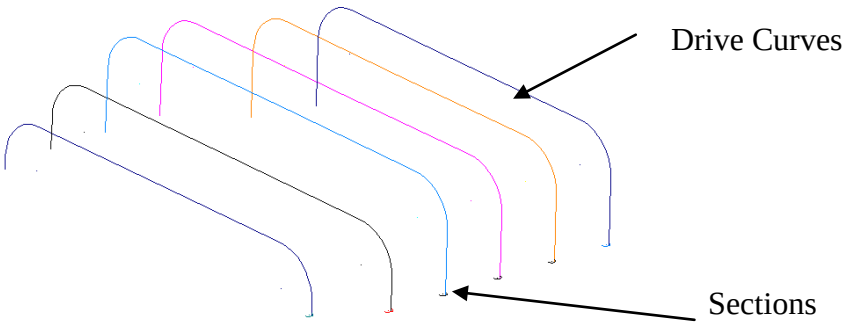


- Create **two Composite Curves**, the first to represent the **Drive Curve** and the second to represent the **Section.**
- **Generate** a **Drive curve** surface.

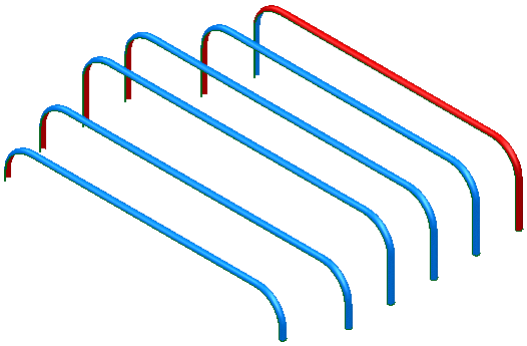


- **Select** and use the **Right Mouse button menu** to **reverse** the **red surface. Unblank (Ctrl + L)**.

The ribs across are going to be created using Drive Curve Surfaces.

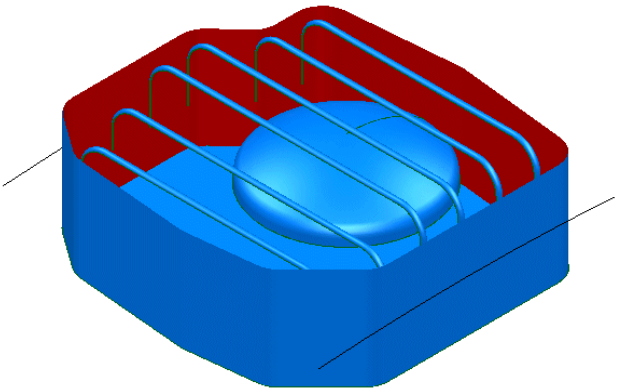


- **Blank (Ctrl + K) everything apart** from the **wireframe shown0**
- **Select all** of the **drive curves** and **select Edit ➔Convert ➔ Wireframe to Composite Curve.**
- **Select all** of the **arcs** and **select Edit ➔Convert ➔ Wireframe to Composite Curve.**
- Create **drive curve surfaces** from the composite curves, using **Apply** on the **form** rather than OK until finished.



The new surfaces are shown.

- **Select** and use the **Right Mouse button menu** to **reverse** any **red surfaces**
- **Unblank (Ctrl + L)**.

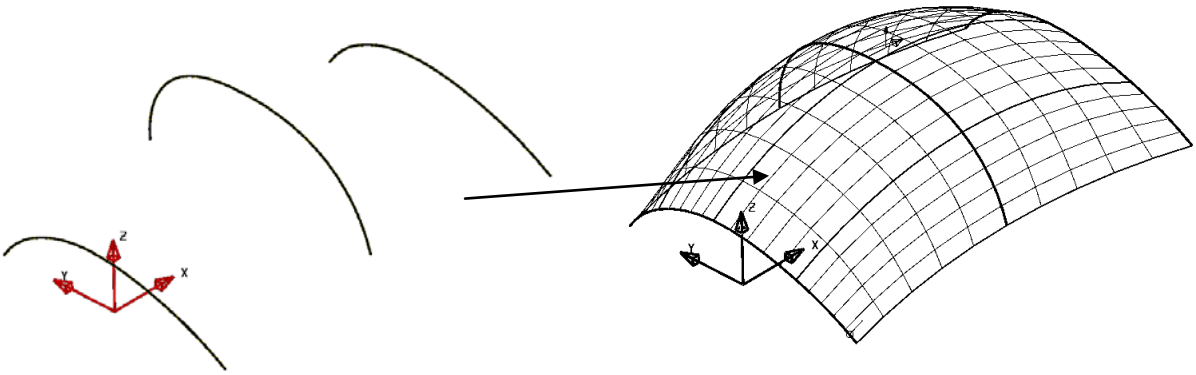


The pump project can now be saved.

- **Select File➔ Save** and **Select File ➔ Close**.

Surface From Separate *Curves*

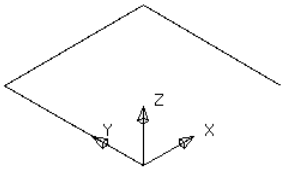
If separate curves are selected the **Automatic surfacing** wizard will use create a **surface *From Separate* curves** option.



The separate **curves** are defined across the surface (**laterals**), which are then linked with curves of best fit along the surface (**longitudinals**).

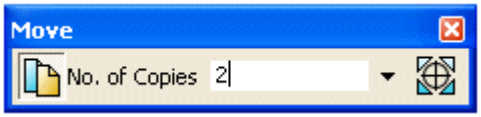
Lateral Curve Example

- Create a **workplane** at **0.**
- Create a **continuous line** from the **workplane**, **10mm** in **Y**, **10mm** in **X**, and **10mm** in **-Y** to produce the 'n-shape'.

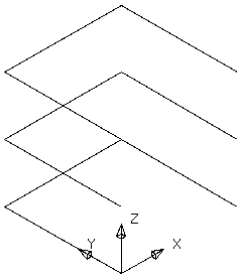


This section will be the basic for the other sections so it will be copied up the Z-axis as individual lines.

- **Select** the **three lines.**
- From the **Edit toolbar** select **Move/Copy Object.**

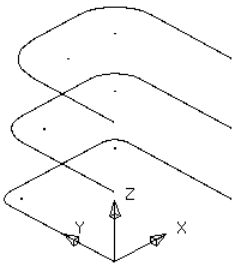
This opens the Move Form. 

- Enter **2** for the number of copies and the value of **0 0 5** in the **position window**, giving you three sets of lines.
- **Dismiss** the **form**.



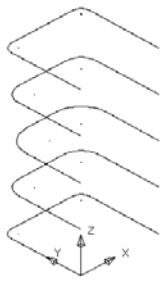
Each composite curve will be filleted by a different radius.

- Make **composite curves** from each set of lines (Alt key and left click).
- Create a **fillet radius** of **1mm** on the **bottom** curve.
- Create a **fillet radius** of **2mm** on the **middle** curve.
- Create a **fillet radius** of **3mm** on the **top** curve.



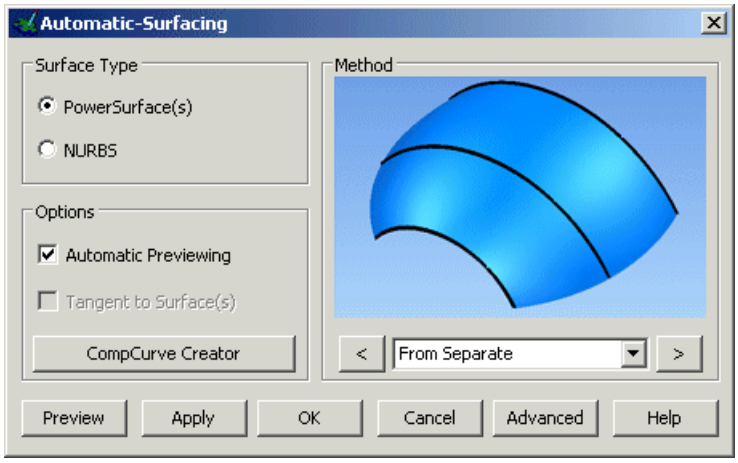
An additional two curves will be copied to produce a total of 5 curves.

- **Select** the **lower composite curve** and **copy** it up the **Z-axis** by **20mm.**
- **Select** the **second from bottom composite curve** and **copy** it up the **Z-axis** by **10mm.**



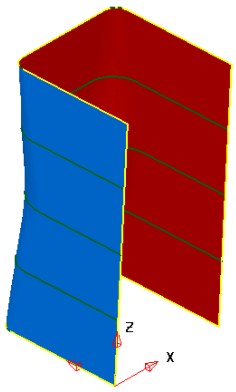
All of the shapes have been turned into composite curves, ready for surface generation. Each of the composite curves will be turned into a lateral on the surface.

- Select **all** of the **composite curves**..
- From the **surface menu** select the **surface wizard.**



The Wizard analyses the selected wireframe and selects the surface type to be created as **From Separate**

- **OK** the form.



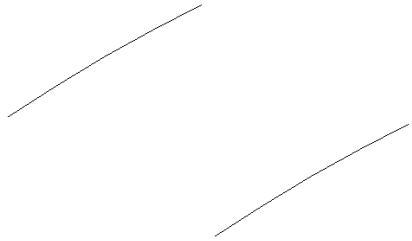
The surface is complete.

- **Select File ➔ Close** and select **No**.

Pump Project Example….continued

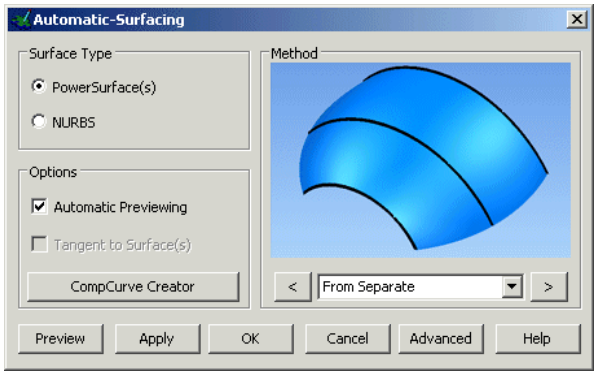
Using the pump example we can use the two curves to make a surface from laterals.

- **Open** the **model pump-project2**.
- **Blank everything apart** from the **two long curves**.



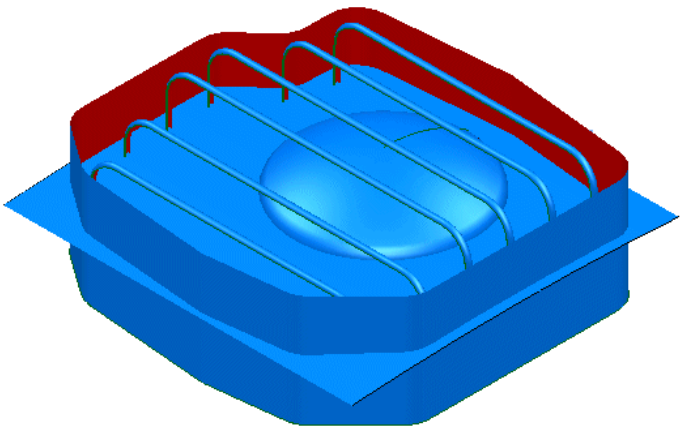
These do not need to be converted into composite curves, as each curve is already a single item.

- **Select both curves**.
- From the **surface menu** select the **surface wizard**.



The Wizard analyses the selected wireframe and selects the surface type to be created as **From Separate**.

- **OK** the form.
- Select **Unblank**.

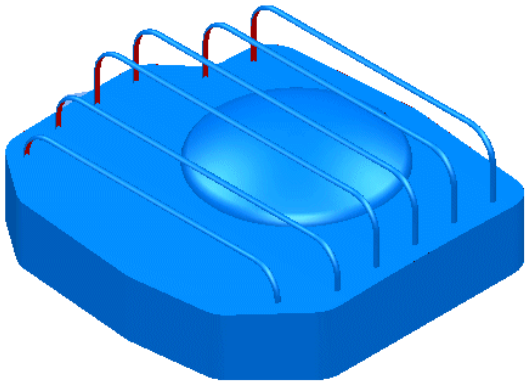


The new **surface** is as shown. The upper and sidewall surfaces now need to be trimmed back to each other (***Limit selection***).

Note: A more comprehensive range of ***Limit selection*** options are covered in **Chapter 8**.

- **Select** and **Blank** all of the **wireframe**.
- **Select** the new top **surface** and in **General Edits** select the **Limit selection** icon (as shown above right).

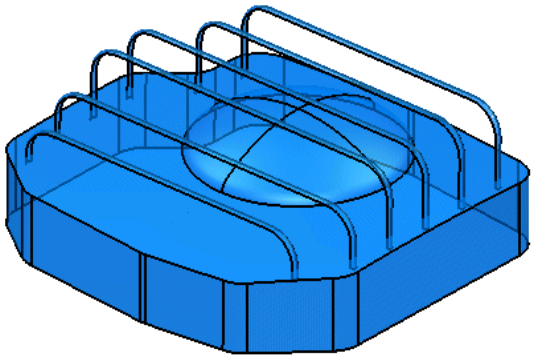
- **Select** the ***sidewall*** **surface** and (if required) keep clicking **next solution** until the correct ***trimmed*** **surface** choice appears before closing the form.



The sidewall and top have been trimmed. It is also required to trim the domed and upper surfaces to each other.

- **Select** the new top **surface** and in **General Edits (**as before) open the **Limit selection** options.

- **Select** the ***domed*** **surface** and (if required) keep clicking **next solution** until the correct ***trimmed*** **surface** choice appears before closing the form.

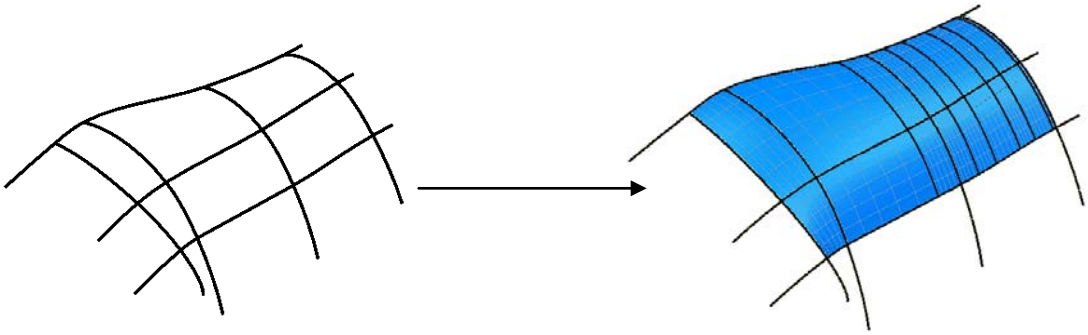


The Upper and domed **surfaces** have been trimmed back to each other.

- Select **File➔ Save and Select File ➔ Close**.

Surface From-Network *of Curves*

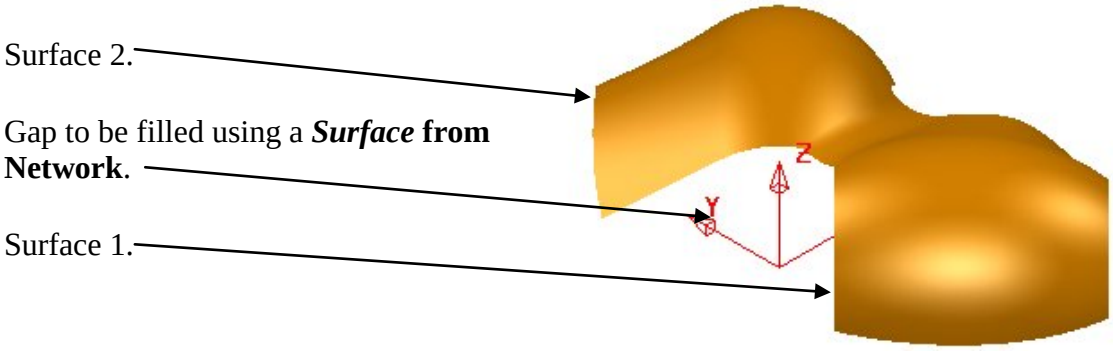
A ***Surface*** **from Network** creates one or more 4 sided, surface patches over over a network of **wireframe**. Surface definition will not occur on any open ended parts of wireframe that extend beyond the network.



Surface Gap Example

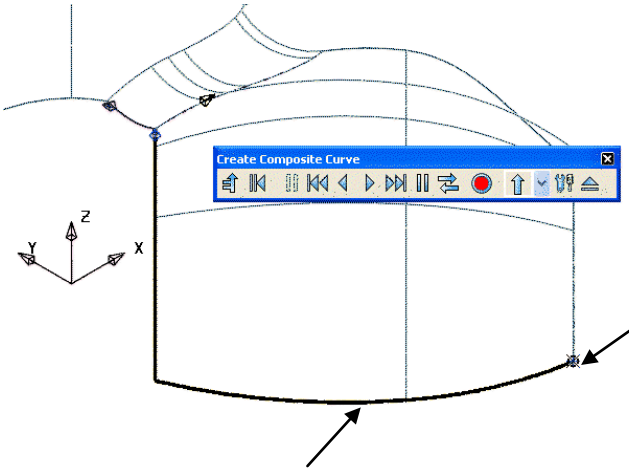
The following example applies the, **from Network - Automatic surfacing** option to blend across a gap in the model.

- Open a **New** model.
- Select **File > Import**, and then select the model **network_example.dgk** from the area **D:\users\training\PowerSHAPE_data\psmodels_n_dgk**
- Select an **ISO 1** view.



To fill the gap with a smooth surface additional geometry will be generated. All characteristics of the existing surfaces will be inherited in composite curves created along and across the gap.

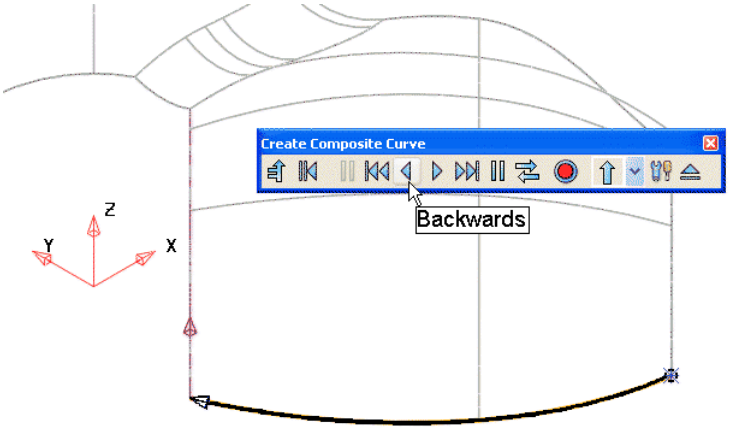
- From the **Curves** menu select **Composite Curve**.



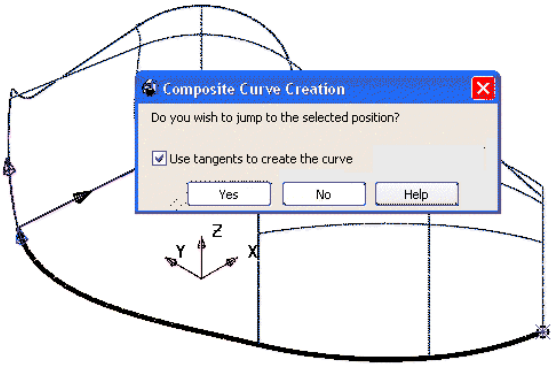
- Select the **Define Start Point** button then click on the **key-point** on the corner of **surface 1** as shown.
- **Select this edge** with the **left mouse button** to create the first part of the **Composite curve**.

Note: the curve continues to the first branch point awaiting further interaction from the user.

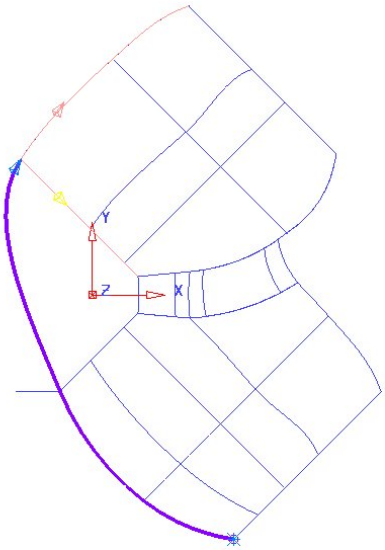
- In the **Composite Curve** toolbar click the **Backwards** button once to go back one span.



- **Click** on the **opposite corner Key-point** of Surface 2 with the **left mouse button** as shown below.

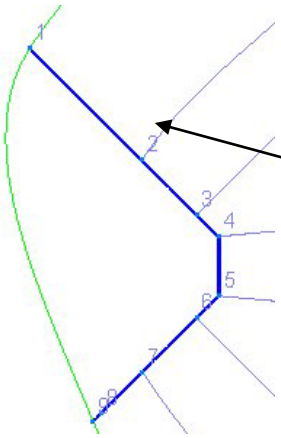


- Check that the default **Use tangents to create the curve** is ticked before Selecting **Yes**.



The **composite curve** jumps to the selected point while maintaining the tangencies relative to both surfaces.

- Select the **Save** button on the **Composite Curve** form.

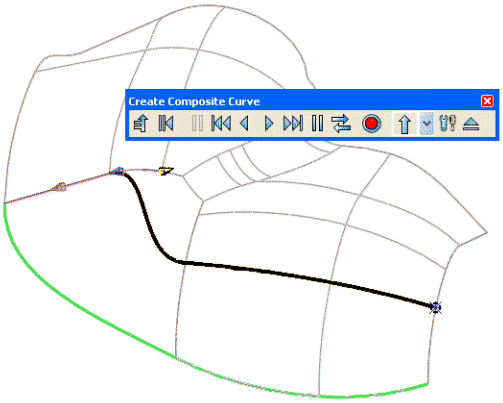


- **Create** a **new composite curve** along the **three remaining edges** as shown.

When a **composite curve** is created along a surface edge it also inherits the tangencies of the **surface**. These will be reproduced by default if the curve is subsequently used to create a new surface from appropriate **Surface Wizard** options.

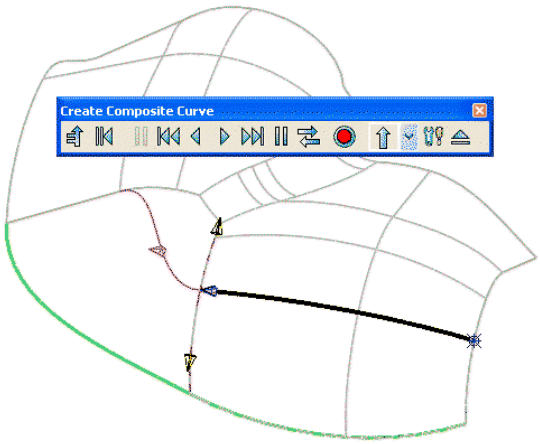
Although enough wireframe is now available to create a **Surface - from Network**, a more accurate alignment will be obtained if additional curves are created across the void.

- Select and **Blank** the last **Composite Curve**.
- Create a new **composite curve** along one of the intermediate curves on the right hand surface and as before attempting to bridge the gap to the corresponding curve on the left hand surface (as shown below).

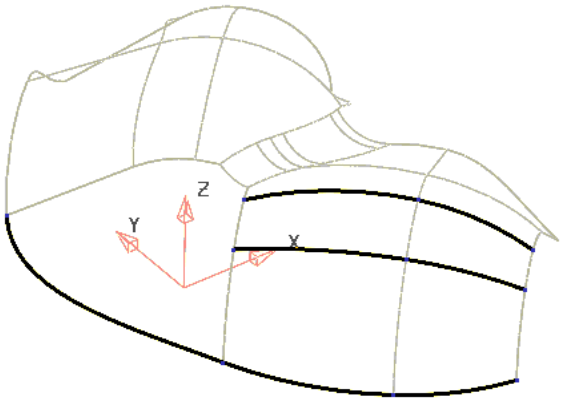


Note: the end of the **composite curve** is aligning to the surface edge and not as required, along the intermediate curve!

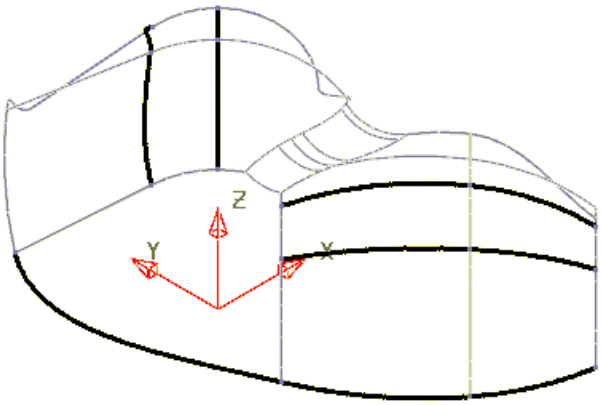
- In the **Composite Curve** toolbar click the **Backwards** button once to go back one span.



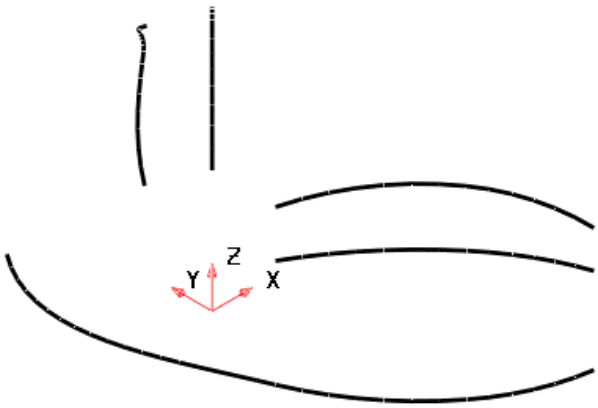
- Select the **Save** button on the **Composite Curve** form.
- Create another **Composite Curve** along the next surface curve on the right hand surface.



- Create 2 **composite curves** along the corresponding surface curves on the left hand surface as shown below.

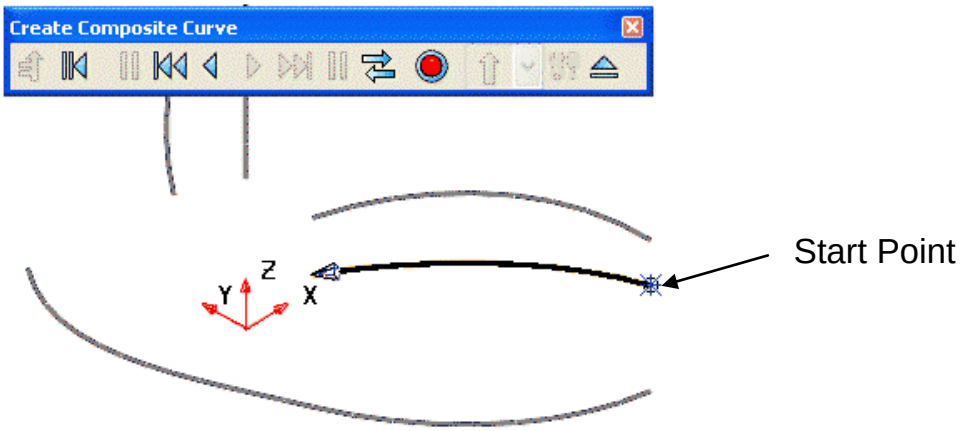


- Select and **Blank** all surfaces on the model.

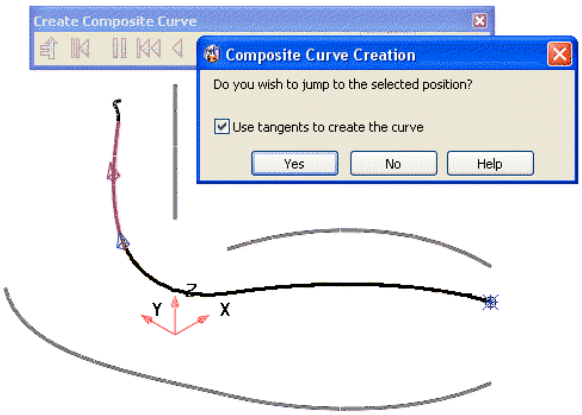


- From the **Curves** menu select **Composite Curve**.

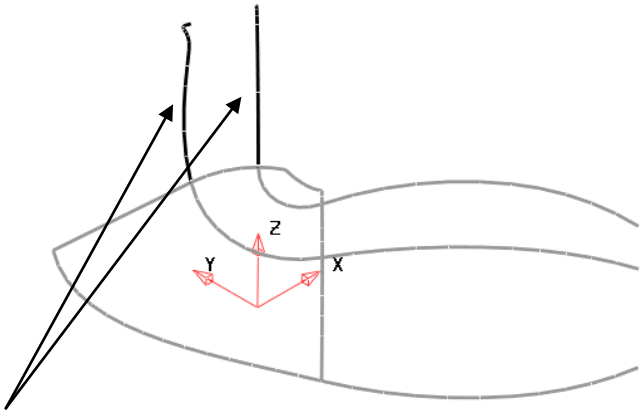
- Select the **Define Start Point** button then click on the **key-point** at the start of the existing **composite curve** as shown.



- Click on the **curve** to include it as part of a new one and then click on the continuation at the end of the corresponding curve, across the gap.

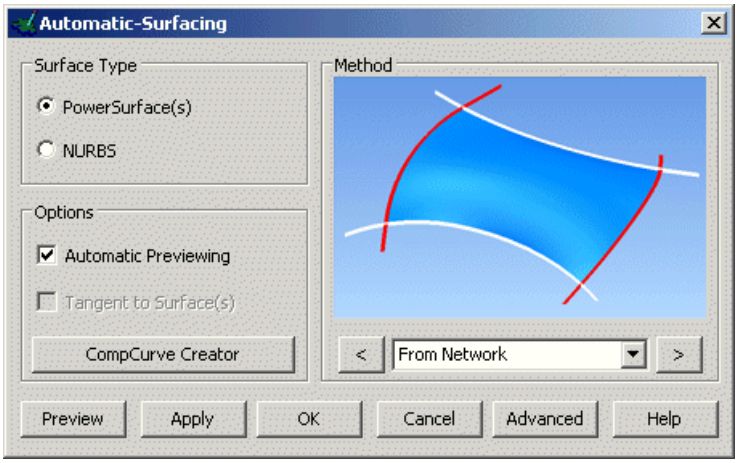


- With the **Use tangent to create the curve** ticked select **Yes** in the **Composite Curve Creation** form (shown above).
- Select the **Save** button on the **Composite Curve** form.
- Repeat the last procedure using the other 2 intermediate curves.



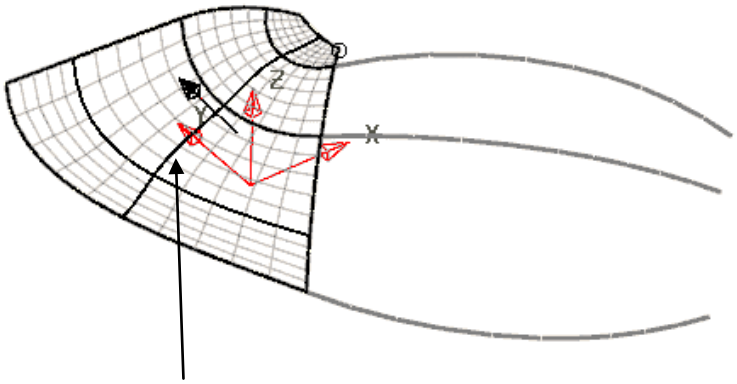
- Delete the 2 curves that are not part of the required surface network.

- Select the remaining curves and from the **surface menu** select **surface wizard**.

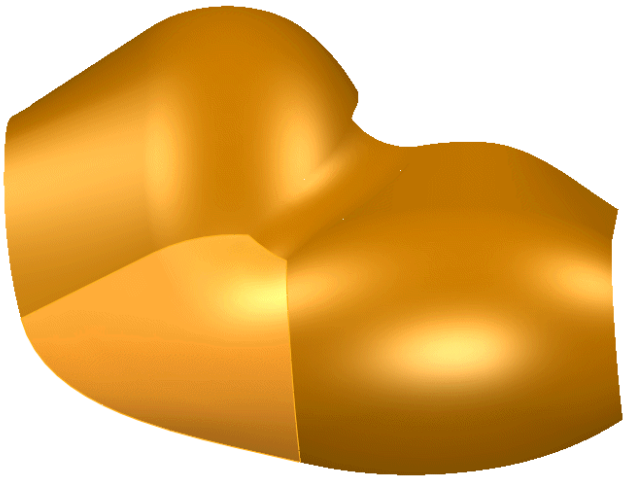


The wizard selects the most likely option to create a surface from the selected wireframe, which in this case is **from Network**.

- Select **OK**.



- Select and right mouse click on the new central curve running down the surface and in the local menu click on **Free tangents and magnitudes** to provide a smoother transition.

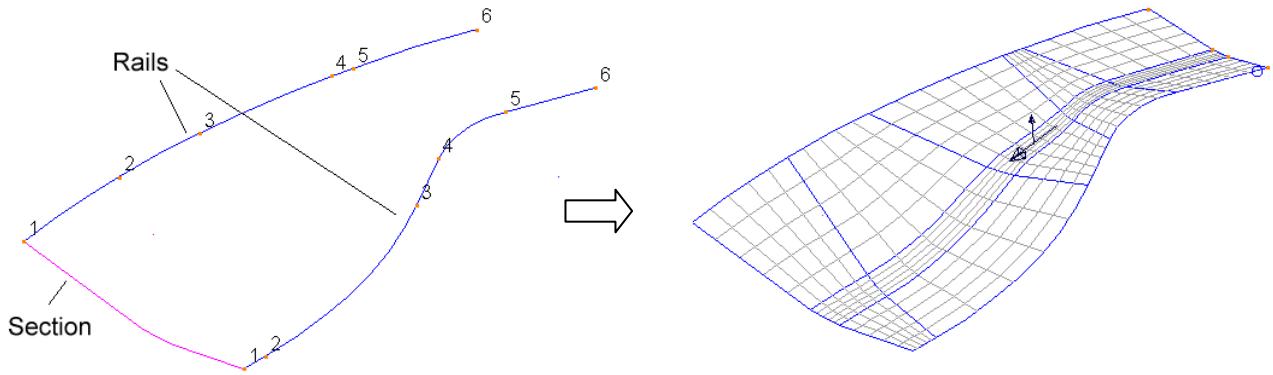


The gap in the model has been filled in with the new surface (shown in lighter shade), which flows smoothly into the adjoining surfaces.

- **Close** the model without saving.

Surface from Two Rails

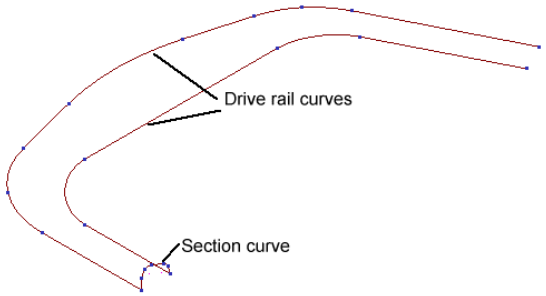
A surface can be generated from a **section**, which is scaled along two **drive rails**, defining the edge of the **surface**.



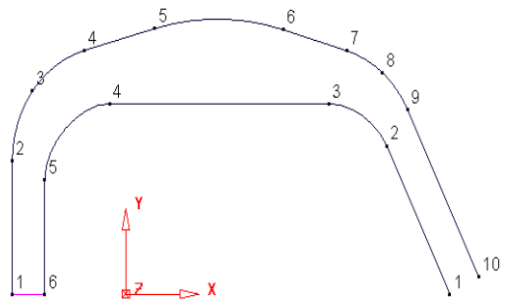
The **section** is scaled across corresponding points along the **drive rails** to generate the **surface**. **Drive rail** pairs must contain the same number of **points** and can both if required form a closed loop. The end points on an open **section** must be positioned exactly on the start point of each **drive rail**. Both the **section** and the **drive rails** must be defined as **composite curves**.

Surface from Two Rails Example

- Select **File > Import**, and then select the model **two_rail_data.dgk** from the area **D:\users\training\PowerSHAPE_data\psmodels_n_dgk**.



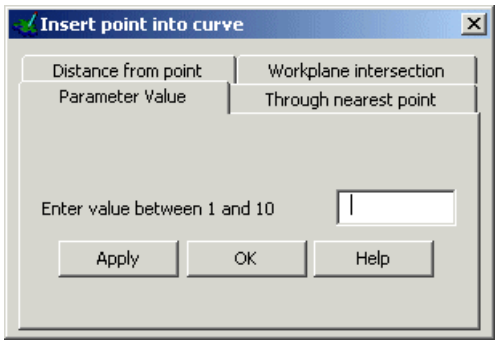
- **Double click** on one of the **drive rail** curves to bring up the **curve toolbar**.
- Shift-select the other composite curve.
- **Select show point labels**.



Each drive rail has a different number of points. Although a surface can be made from this, the distribution of the internal curves may not be desirable.

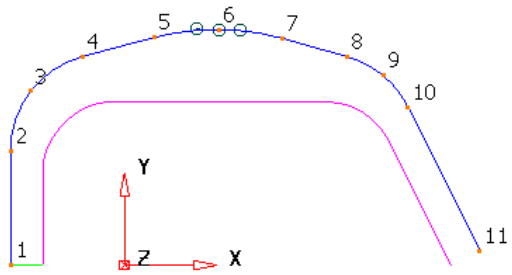
To fix this, even number of points and alignment need to be generated.

- **Select** the **top curve** (10 points).
- From the **curve toolbar**, select **Create a point.**



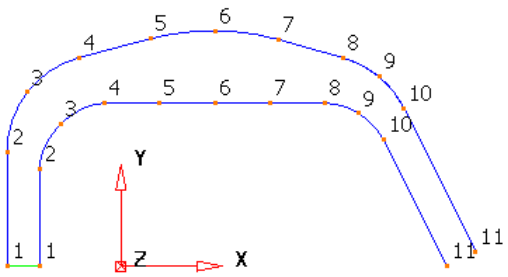
The insert point form appears. For this example the parameter value tab is used.

- Select the **parameter tab** and enter **5.5** and press **Apply** and then **OK**.



When adding each point, the curve is renumbered and it is therefore easier to add points from the last number backwards.

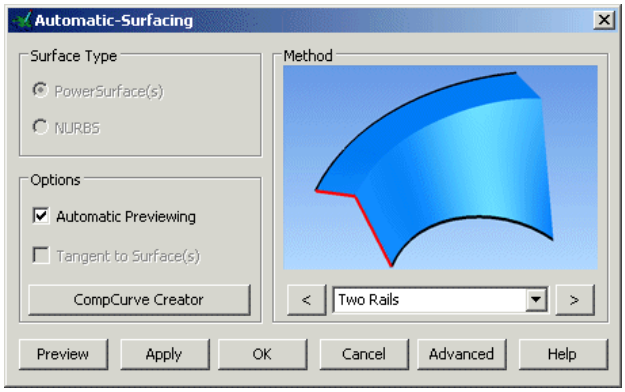
- **Select** the **bottom curve** (6 points).
- Select **Reverse curve** then **Create a point**
- Select the **parameter tab** and enter **4.5** and press **Apply**.
- Enter **3.5** and press **Apply**.
- Enter **4.5** and press **Apply**.
- Enter **3.5** and press **Apply**.
- Enter **2.5** and press **Apply and then OK. Select both curves**.



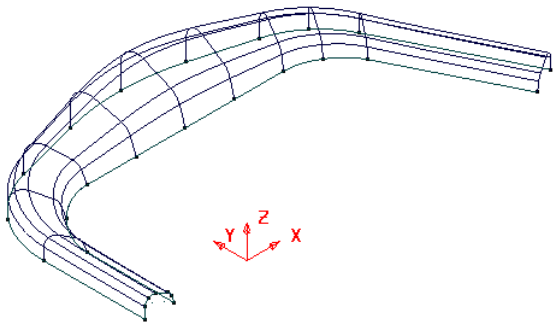
Each curve has the same number of points so when the surface is generated it will align smoothly.

- **Select** all of the **composite curves**.

- From the **surface menu** select the **surface wizard**.



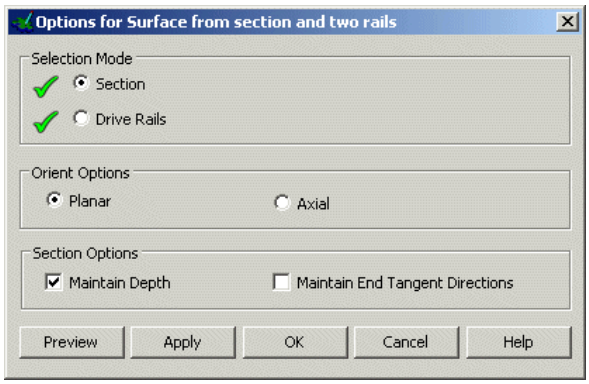
This time the wizard recognises that a Two Rails surface is the best choice for surface creation.



The preview of the surface should appear as in the picture to the left.

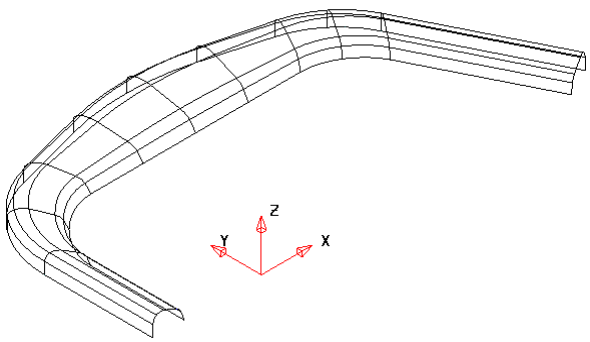
Note: The section height has scaled in proportion to the distance between the drive curves at each section position.

- Select the **Advanced** button from the bottom right of the form.



This form gives the user more control over the way in which the surface is generated from the selected wireframes.

- Tick the option to **Maintain Depth** and **Preview** again.



This time the height has been maintained to that of the original section.

- **Select OK**.
- Select and **Delete** the **surface**.

7. Advanced Surfaces

Introduction

The ***Advanced Surfaces*** options are located in the **Surfacing toolbar** after the **Automatic Surfacing Wizard**, **Primitives, Revolution** and **Extrusion** icons.

The ***Advanced Surfaces*** options shown horizontally above include from left to right:-

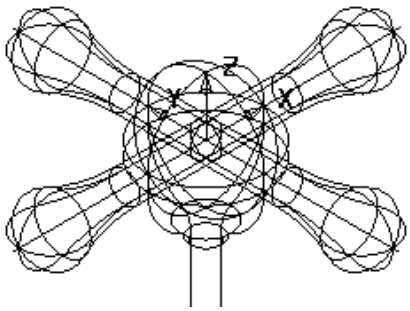
Bead, Patch, **Draft**, **Split**, Extension, **Fillet**, Blend, and Wrap Triangles (designer module).

The options in bold print are covered in the following chapter.

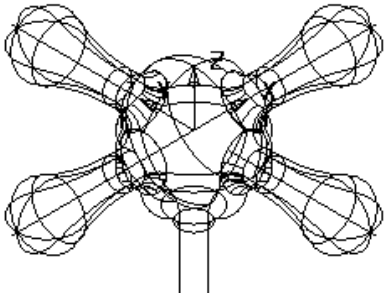
Fillet Surfaces

PowerMILL Modelling can create both fixed and variable radius **Fillets** between 2 or more surfaces. A **fillet surface** is best described as the developed outside contour of a ball if rolled between the surfaces. Where the ball makes contact defines the outer edges of the fillet to where (by default) the original surfaces are trimmed back.

Before Filleting

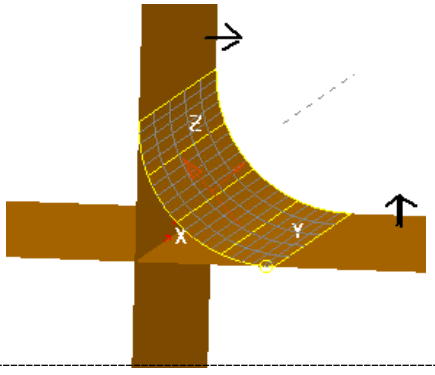


After Filleting

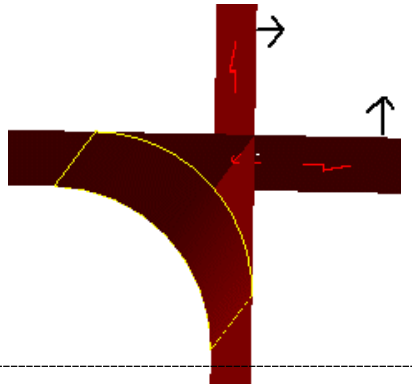


PowerMILL Modelling will create **concave** fillets running from the outside (User defined colour side) or **convex** fillets from the inside, (Red side) of the host surfaces. The filleting direction for each surface is marked by an arrow, which if clicked will reverse direction causing the fillet to run from the other side.

Concave



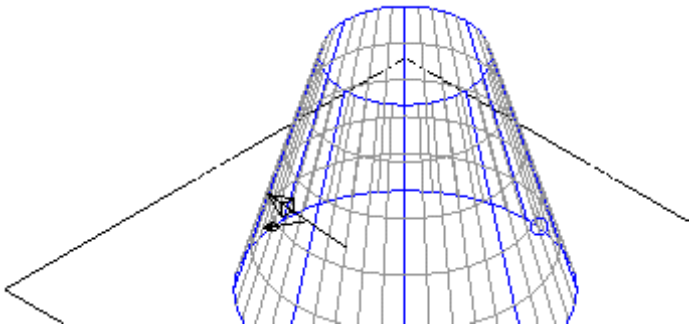
Convex



Basic Fillet Example

This example demonstrates the basic filleting options between 2 surfaces.

- Create a **Plane Primitive** of length **100** and width **100** at **0 0 0**.
- **Create** a **Cone Primitive** of base radius **30**, top radius **15** and length **50** at **0 0 0**.
- Right click over the cone and select **Convert Surface**.

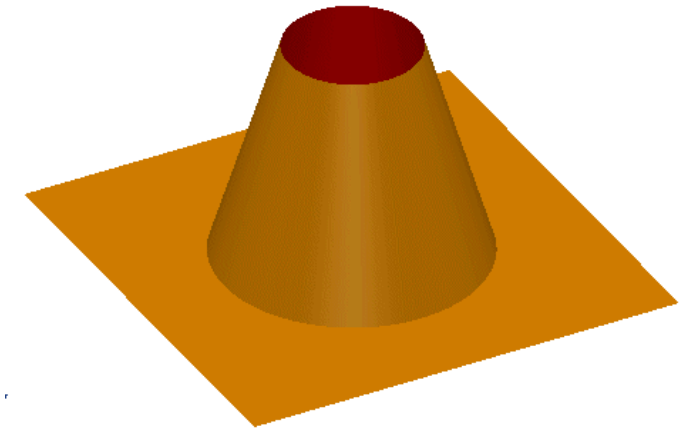


A selected Power Surface shows more detail.

The small brown arrow points outwards, indicating that this is the outside edge of the surface. The larger brown arrow indicates the direction the surface flows and is not used in filleting.

Another way to show the inside and outside of the surface is to shade the model. By default PowerMILL Modelling displays the outside of surfaces as **gold** and the inside as **red**.

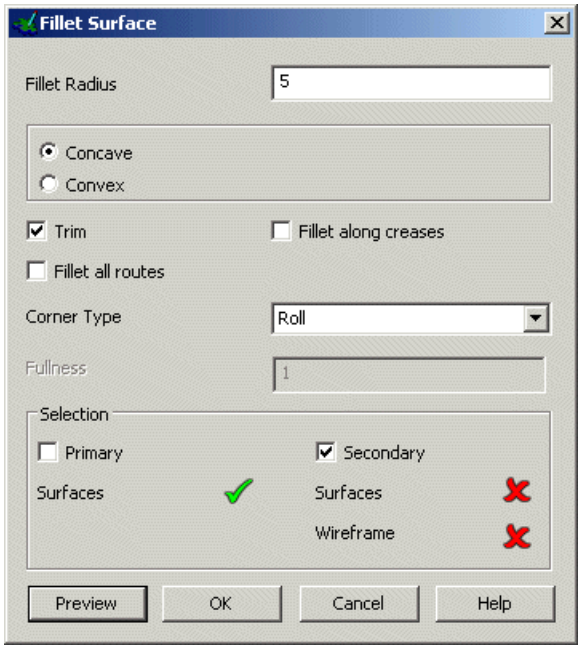
- Select **Shaded** view.

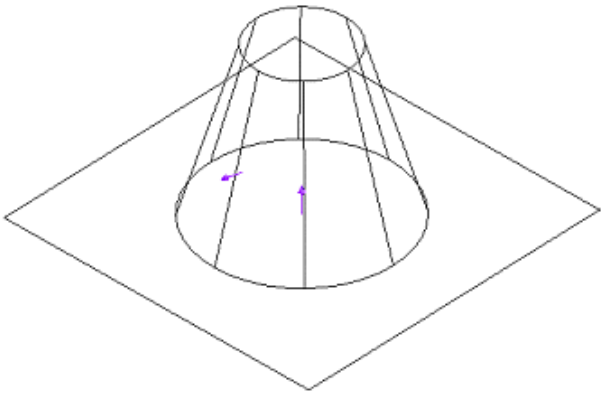


Both surfaces should be shaded gold on the outside. If not then you can right click on any red surfaces and select **Reverse** from the available menu.

- Select **both surfaces** and select the **Wireframe View**.
- From the **Surface menu** select **Fillet Surface**.

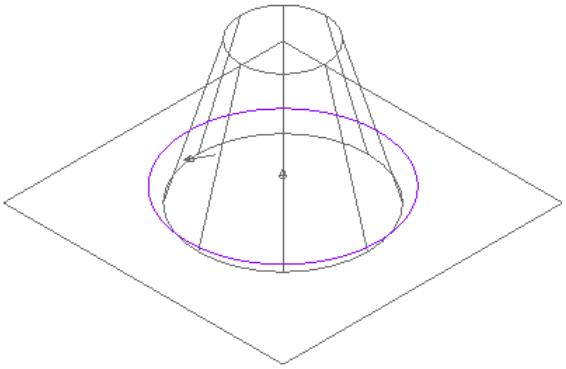
Once this option has been selected, the **Filleting** form appears with a suggested concave fillet radius.





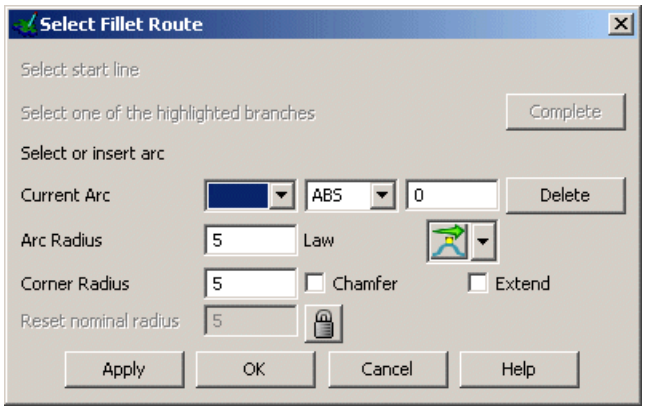
The surface direction arrows are displayed which if clicked will turn the surface inside out, Arrows point away from the ***gold*** side of surface.

- Select **Preview** on the Fillet Surface form.



The fillet track is displayed as the centreline of the rolling ball as it runs along the surfaces. If that is not what you wanted then you can change the values and surfaces and hit preview again. If it is acceptable then select OK.

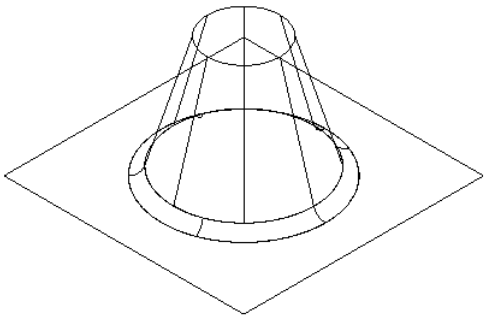
- Select **OK** on the form.



The **Fillet Route** form appears.

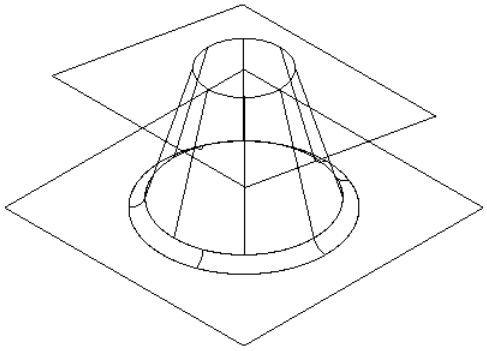
The preview curve now turns yellow to show that it is selected. As there is only one track available, pick OK. When you have several independent fillet tracks, you will have to select one and then Apply and then select another track and so on until you have finished and hit OK.

- Select **OK** off the form.



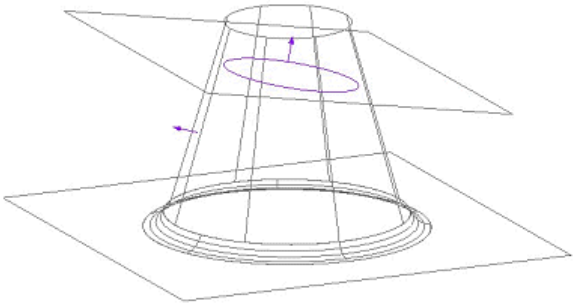
The fillet surface is produced and the cone and plane trimmed back to the fillet.

- Create a **Plane Primitive** at **0 0 40** with a **length** and **width** of **80**.
- Double click on the plane and in the plane form select a **Y-Twist angle** of **10 degrees**.

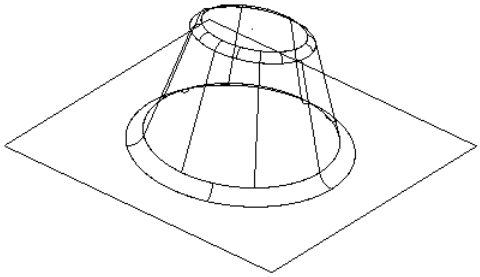


This top surface will be filleted to the cone, but this time the fillet will be on the inside of the cone.

- **Select** the **Cone** and the **angled plane surface**.
- From the **Surface menu** select **Fillet Surface**.
- Enter a **fillet radius** of **3mm**, select **Convex** and press **Preview**.



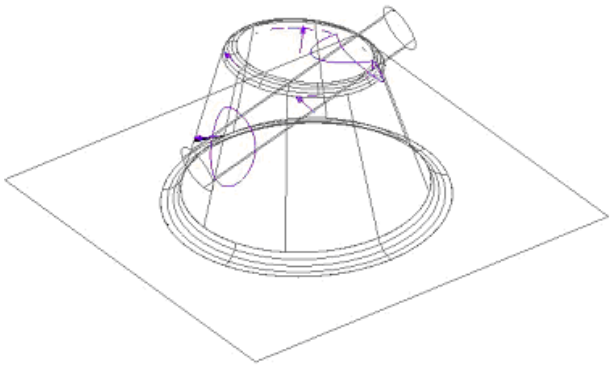
- **Select OK** (fillet route) and then **OK** (fillet surface).



The fillet is produced trimming back the top of the cone and the plane.

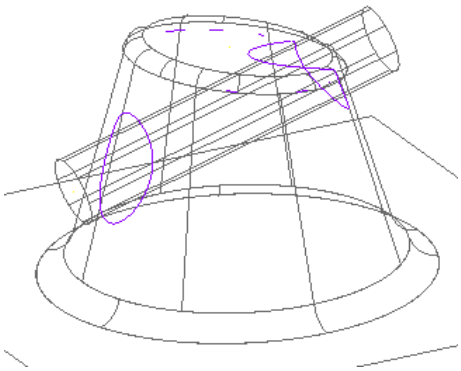
Fillets can also be produced with several surfaces.

- **Select** the **X plane** and **create** a **Cylinder Primitive** at **–30 0 20**.
- **Change** the **radius** to **6**, **length** to **60** and **rotate** it with an **X-Twist** of **–15**.
- **Select** and **reverse** the **surface** (red on outside).
- **Select all** of the **surfaces apart** from the **lower fillet** and **plane**.
- From the **Surface menu** select **Fillet Surface**.
- Enter a **fillet radius** of **2mm**, select **Convex** and press **Preview**.



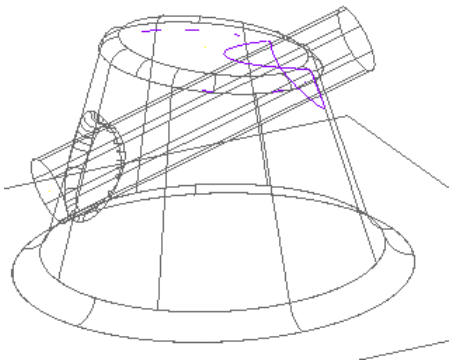
The available fillet routes are displayed. The cylinder needed to be reversed to control where the fillet occurs.

- Select **OK**.



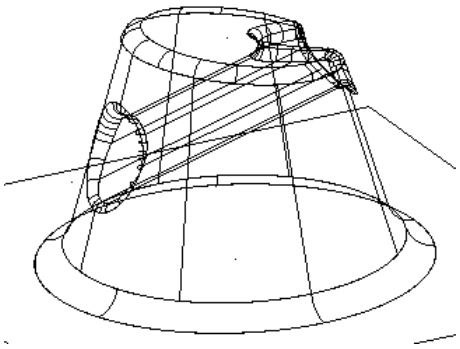
In this case, PowerMILL Modelling has identified two complete fillet tracks and a few other possibilities. As PowerMILL Modelling allows you to specify which track you want to use you can use as little or as many tracks as required.

- Select the **first fillet track** nearest the plane (lowest one), which turns yellow.
- Select **Apply**.



The first fillet is produced and PowerMILL Modelling waits for another fillet track to be selected.

- Select the **second** track nearest the top and press **Apply** and then **OK**.



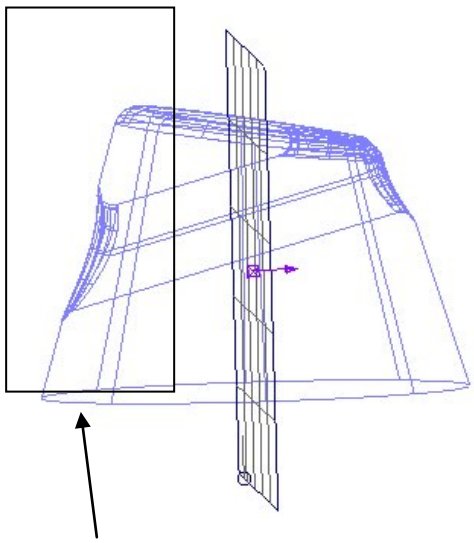
All of the other tracks are ignored and the surface is limited back to the fillets. By reversing the cylinder, the fillets are produced inside, rather than outside.

Filleting using Primary and Secondary sets of Surfaces

Normal filleting will check every selected surface against each other to find the fillet path required. On a large job, this can take some time and it may be awkward to pick the actual fillet path out.

By using the Secondary surface option, this allows to identify two sets of surfaces that the fillet will run between. With this option, you select the first set of surfaces as your primary surfaces, select the fillet icon and then pick your second set of surfaces, which automatically become the Secondary set. PowerMILL Modelling now knows where to generate the fillet.

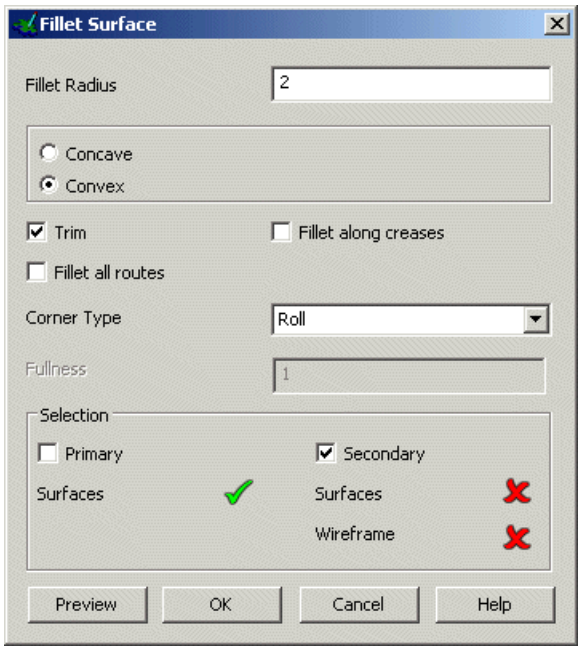
- **Select** the **lower plane** and **fillet** and **delete** them.
- **Select** the **X plane** and **create** a **Plane Primitive** at **0 0 20** with a **width** of **110** and a **length** of **60**.
- Change the direction of the plane, if required, so the gold side is on the X+ direction as shown.

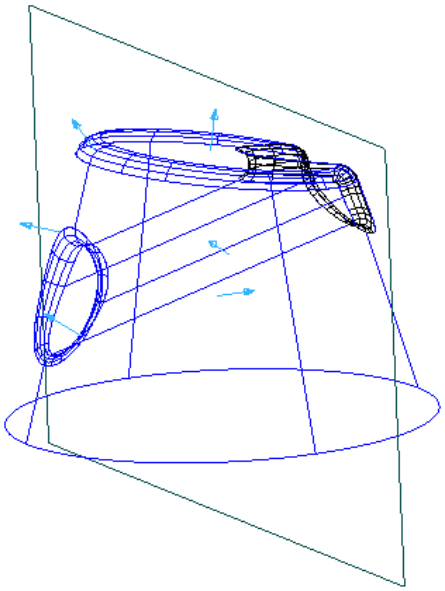


This set of selected surfaces will become the secondary set. The fillet routes are calculated only for the intersection between the primary and secondary surfaces. This results in a quicker calculation for the fillet routes. As less routes are produced it is also easier to select the right ones.

- **Drag** a box over the **surfaces** on the left as indicated.

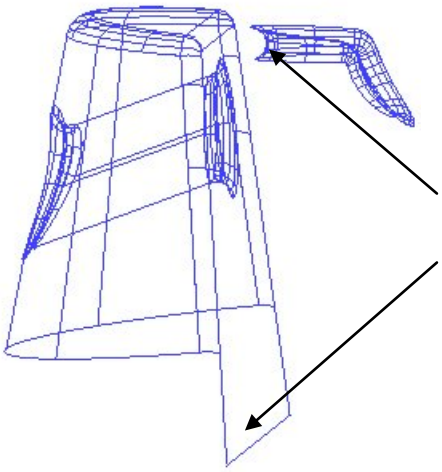
- Select **fillet surface**.
- Set a **radius** of **2mm** and **Convex**.
- Select the **Plane surface**.





The selected surface turns pink and the secondary surface option is ticked.

- Select **OK**.
- Select the **first track** and then select the **Apply** button.
- Select the **last track** and then select the **Apply** button.



The fillets are produced and most of the other surfaces have been trimmed back.

- **Delete** this remaining surface.
- **Limit** the bottom of the plane back to complete the model.

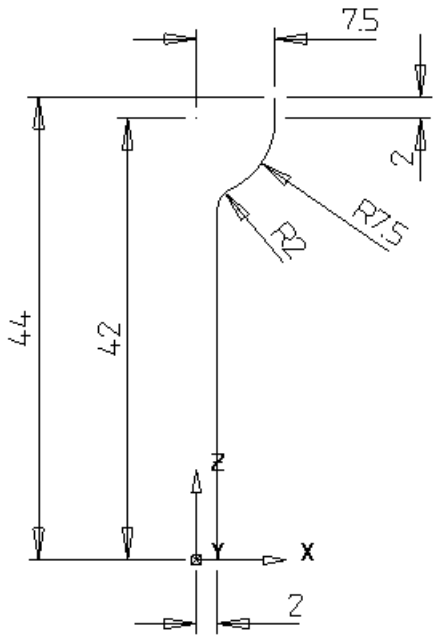
Hint: create a line from the bottom ends of the cone. Limit the surface to the new wireframe.

- Select **File➔ Close** and then **No**.

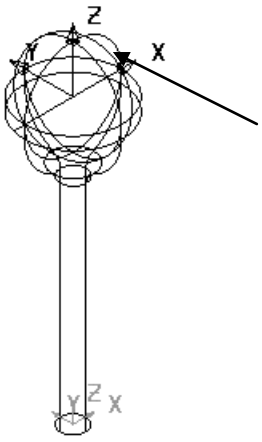
Further Filleting using Primary and Secondary sets of Surfaces

The following example uses a simple tap design to demonstrate **fillet** creation between two sets of **surfaces**.

- Select **Create New Model**.
- **Generate** the following **wireframe** up the **Z axis**.



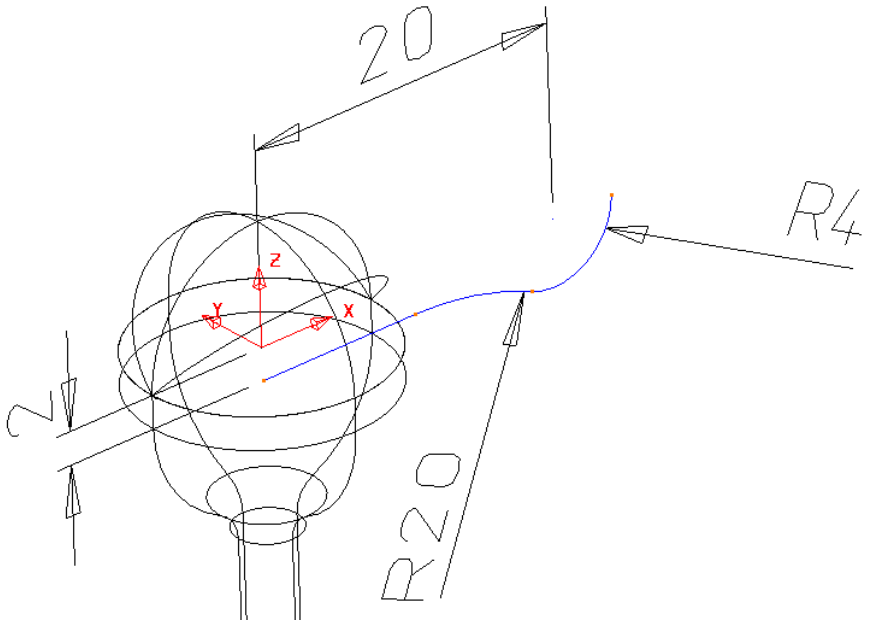
- **Select** the **Z plane** and **create** a **surface of revolution** from this shape.
- Create a **workplane** at **0 0 44**.
- Generate a **Sphere Primitive** of **radius 7.5** at the new **workplane**.
- **Select** the **Workplane** then from the edit toolbar, select **Limit**.
- **Select** the **sphere**.



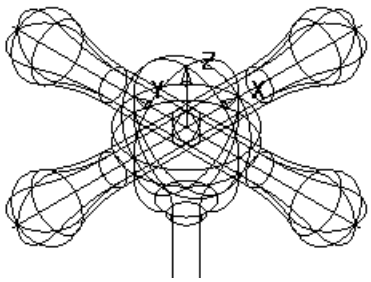
The sphere is then limited to the workplane and the top half should be kept. This will only work if the correct **Principal Plane** is set.

- **Dismiss** the **form**.

- **Generate** the following geometry for the tap arm shape around the workplane.



- Create a **surface of revolution** around **X Principal Plane**.
- **Rotate** and **copy** this surface **3 times** by **90 degrees** around the **Z Principal Plane** to make the four arms.

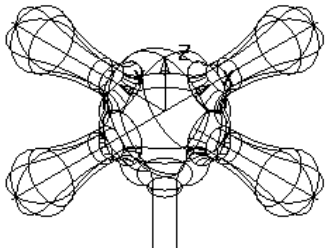


The four arms need to be filleted to the central section. Make sure that when shaded, all of the surfaces are gold. We do not want to fillet each arm to each other or waste time generating the route so we are going to use the Secondary surfaces option.

- Select the **central section** (the revolved surface and the sphere).
- **Select fillet surface**.
- **Select** the **four** arm **surfaces**.

On the form the option secondary surfaces becomes ticked.

- Enter a **concave radius** of **2**.
- **Press OK**.
- **Select** the **fillet tracks in turn** and **press OK** to finish the model.



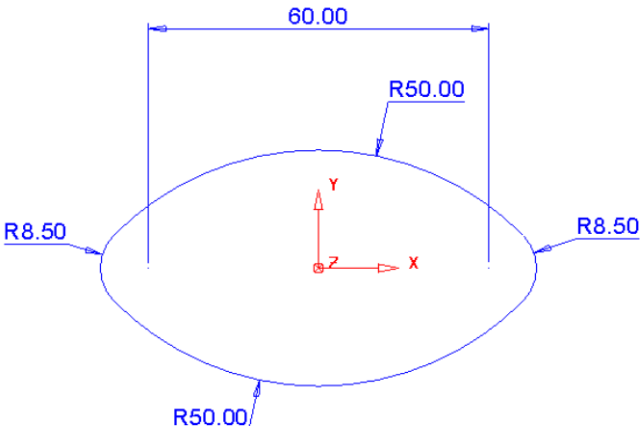
- Select **File➔ Close** and then **No**.

Variable Radius Fillets

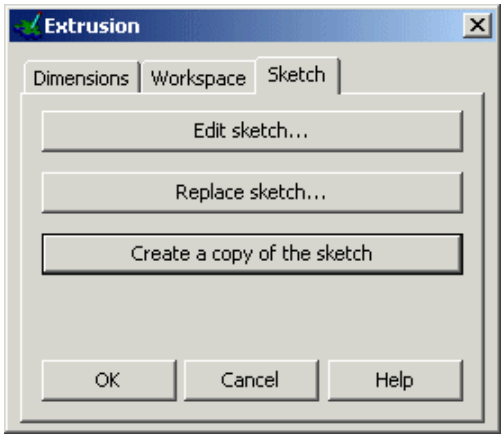
Variable fillets are easily created along the fillet track using the mouse to identify KEY points or using functionality within the form to position the fillet arcs either by Parametric, Relative or Absolute values.

Example

- Select **Create New Model**.
- Create a **Workplane** at **0**.
- Create two circles with **radius 8.5** at **X 30** and **X -30**.
- Create an **arc through three points** of **radius 50** either side of the two circles to form the following shape.



- Create a **composite curve** from the wireframe.
- Generate a **Surface Extrusion**.
- Change the **Length** to **60** and from Sketch, select **Create a Copy of the Sketch**.

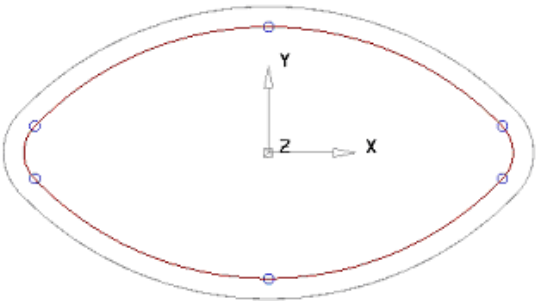


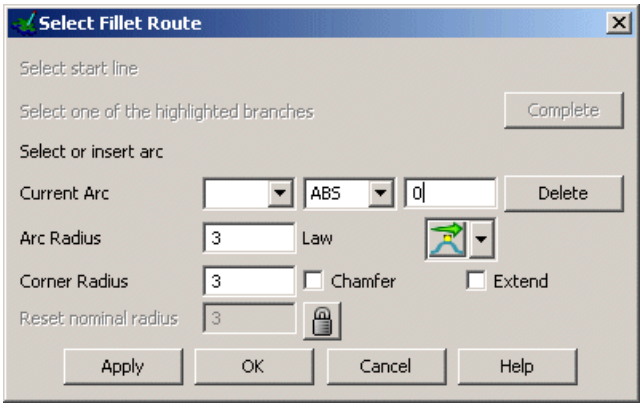
When an extrusion is made the default option is to turn it into part of the surface.

The create a copy of the sketch option, creates a copy of the original composite curve so that it can be used to create a Fill in surface at the bottom of the extrusion.

- **Press OK**.
- **Select** the **composite curve** and create a **Fill in surface**.
- **Reverse** the **surface** so the **red side** is facing up the **Z axis**.
- **Delete** the **composite curve**.
- Select **both surfaces**.
- From the **surface menu,** select **Fillet surface**.
- Input a **fillet radius** of **3** select **Convex** and press **OK**.
- Select a **view down Z**.

The fillet track is displayed with circles showing KEY points that can be snapped to using the mouse. By snapping at these KEY points an arc of the initial radius is created. The value of this radius can be modified in the Arc Radius area of the form.

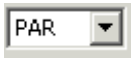




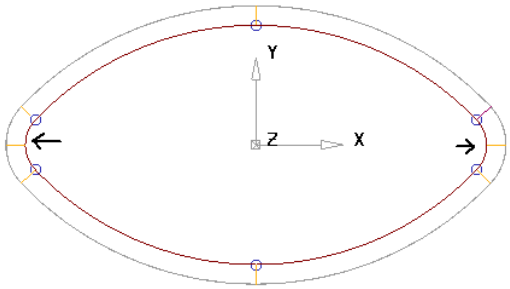
- **Snap** to **each** of the **6 circles** when the word **KEY** appears.
- Create **6** arcs by snapping **KEY** points around the fillet route starting at the right and working your way around clockwise as shown below.

A radius appears for each point and this becomes numbered in the current arc part of the form. Individual arcs can be selected from this form or by manually clicking on them. The radius can be changed in the form or dragged manually.

New points to place radii on the fillet track can be entered by clicking on the track or by entering a parameter position. To enter a parameter position, select the nearest fillet and, check the number on the form in the Current Arc box, work out the number required, change the ABS to PAR, enter the value such as 4.5 and press Return.



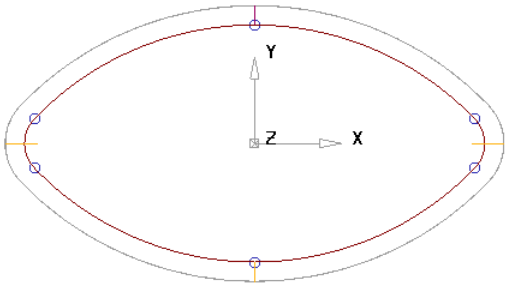
- **Insert** two **new radii between** the **two** at **each side**, as shown.



The radius for these new arcs can be changed.

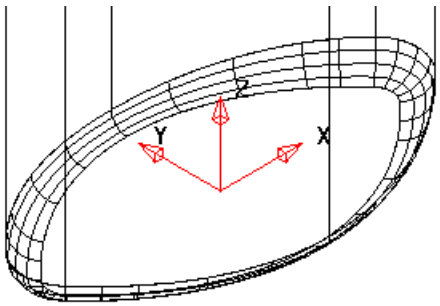
When there is an arc the fillet value is fixed at that point. If the next radius value ids different the radius will change along the distance.

- Select the **new arcs** in turn and **change** the **radius** to **5mm**.
- **Select** the **arcs** (in turn) **either side of the new larger arcs** and select **Delete** off the form (4 arcs in total).



When there is an arc the fillet value is fixed at that point. If the next radius value is different the radius will change smoothly along the distance.

- Select **Apply**.

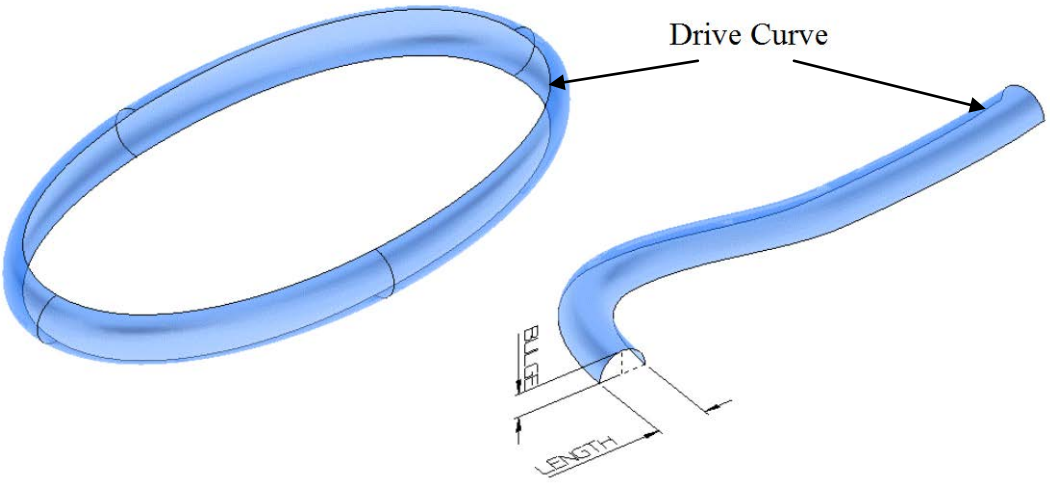


The variable radius fillet has been produced.

- Select **File➔ Close** and then **No**.

Bead Surfaces

A **Bead Surface** is defined by specifying a **Length** and a **Bulge** across a drive curve. They can be used to quickly form decorative features on products or more functional features such as 'Draw Beads' on press tools.



Bead Example

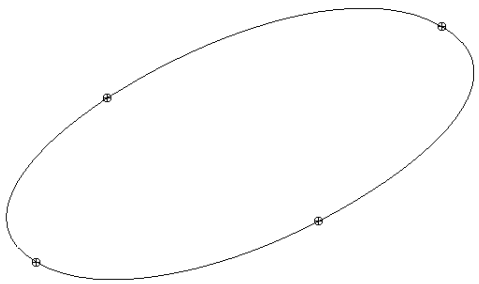
This example creates a curve from manually input points, which are then used to generate a bead surface.

- From the **workplanes menu** Select **point creation.**
- Enter **4 points** by typing in the following co-ordinates:

-50 0 0
0 30 0
65 0 0
0 –30 0

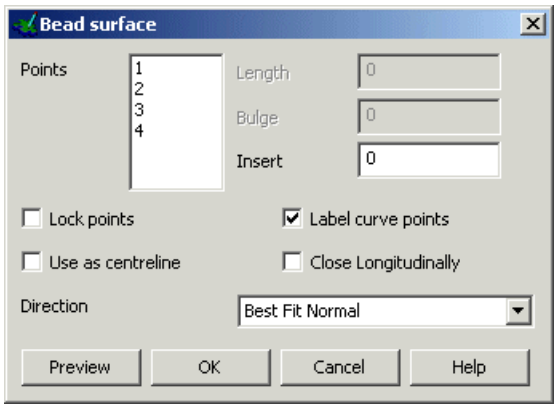
The four points can be snapped onto when creating a bezier curve.

- From the **Curve Menu** select **Create a Bezier Curve.**
- **Click each point in order** and **re-click** the **first point** to close the curve.

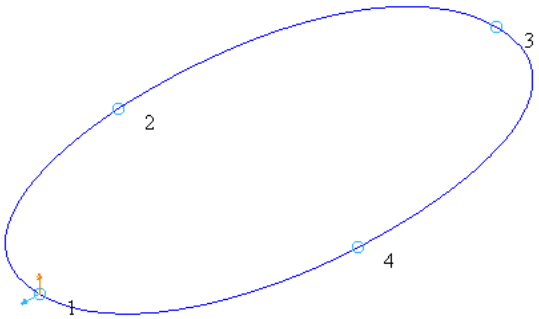


A closed bezier curve is produced.

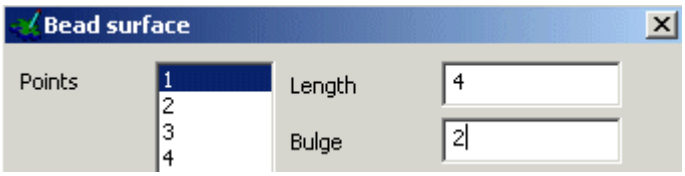
- From the **surface menu** select **Create a bead surface**.



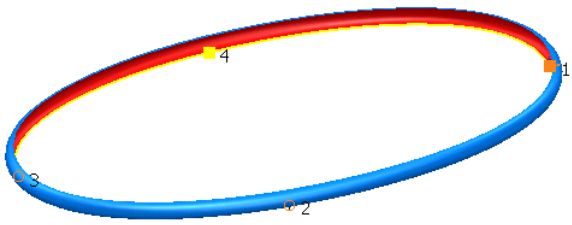
Each Point displayed in the **Bead** Surface form is relative to a position along the curve length. It is these positions that can then have **Bulge** and **Length** applied to them to create the surface.



- Select **Point 1** from the list and set **Length 4** and **Bulge 2**.

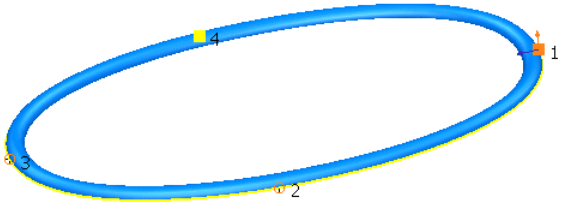


- Select Point **4** from the list and set **Length 4** and **Bulge 2**.
- Select **Preview**.



The surface is previewed with a **Bead Length** of **4** and **Bulge** of **2** through all points.

- Set the **Direction** to **Radial** and select **Preview**.

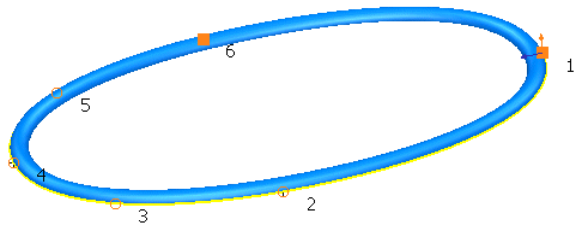


The surface is previewed with a **radial** form along the length of the curve.

Additional points can be inserted into the curve to modify the surface.

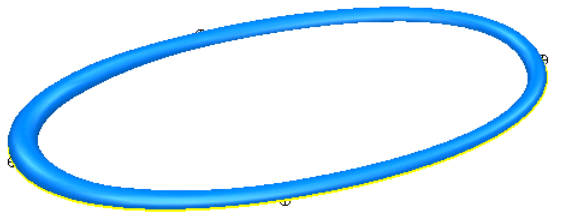
- **Insert** a point halfway between the existing points 2 and 3 by entering **2.5 and pressing Return.**

- **Insert** a point halfway between 4 and 5 using a value of **4.5** and **pressing Return.**



New points have been created along the curve and the curve renumbered.
Length and **Bulge** can be modified at these points.

- **Delete** any **numbers** on the **Insert field** to leave it **blank.**
- Select **Point 3** from the list and set **Length 5** and **Bulge 3**.
- Select **Point 5** from the list and set **Length 5** and **Bulge 3**.
- Select **Point 4** from the list and set **Length 6** and **Bulge 4**.
- Select **OK** to create the surface.

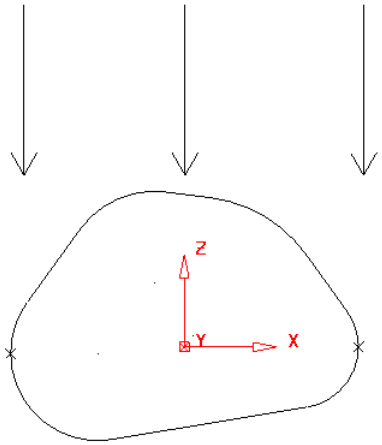


The surface is created with a varying **Bead** form.

Select **File** ➔ **Close** and then **No**

Split Surfaces

Split surfaces are generated from split curves defined on a component. The split curve is the separation point of the tool, which would produce the component. A surface's natural split is the curve around the model where the surface just dips out of sight. PowerMILL Modelling looks down the Z-axis to find the points along the surfaces where it dips out of sight.



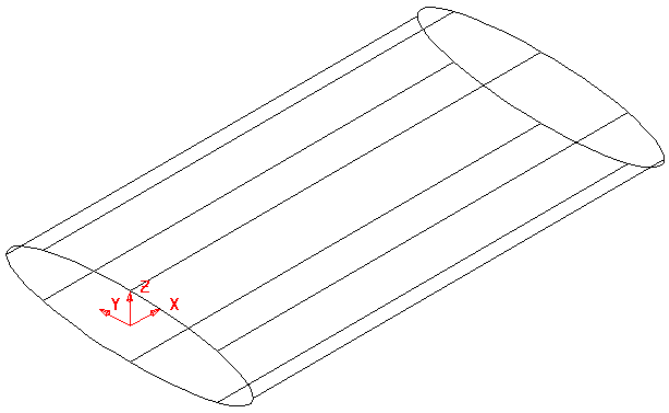
With vertical walls, the split surface command will not find a split, as there is no change in angle, so you have to decide where the split line occurs yourself, by generating a composite curve of the route along that vertical surface.

The following example works through creating a component, finding the natural split line, and producing the split surface. As there are fillets next to the vertical walls it will use the edge of the fillets to complete the split curve.

Draft Example

In this example a primitive cylinder will be modified to produce a simple part. A split line for the part will be calculated for the surfaces and a new split surface will be made.

- Select **Create New Model**.
- Create a **workplane** at **0** and set the **X** principal plane.
- Create a **Cylinder Primitive** at **0** with a radius of **30mm**, and length **100mm.**
- **Scale** the surface by **0.3** in the **Z-axis**.
- **Convert** the **surface**.



We can modify this surface in a number of ways

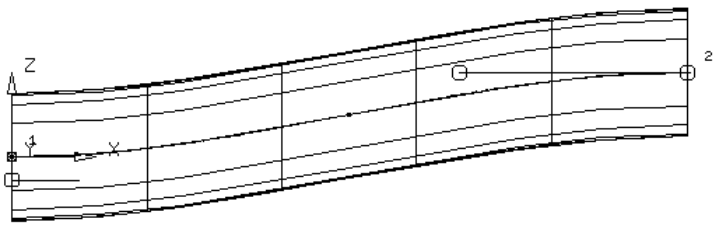
Moving lateral 2 upwards would re-float the longitudinals giving them a straight

In order to give a curved shape to the surface we will need to create a spine. A spine is a curve which passes through the centres of the sections on a surface and may be used to control their orientation. If a spine is generated and a spine point moved upwards, the longitudinals will remain horizontal where they met the laterals, producing a curved result.

- **Double click** the **surface** to bring up the **surface edit toolbar**.
- From the **surface edit toolbar** select **Create Spine**. (located in the **Add curve** options).

This will create a spine running through the cross sections of the surface, shown as a dotted line. This spine can be deleted without affecting the surface.

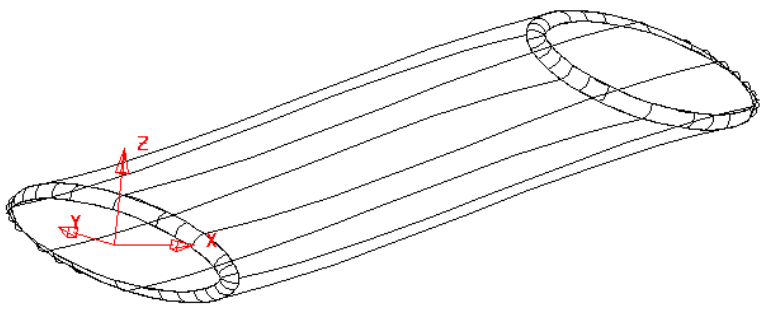
- Select **Point 2** on the **spine** by clicking on it.
- From the **Right mouse** menu, **untick apply smoothing to point edits**.
- **Move** the spine point **10mm** up the **Z-axis by typing 0 0 10** in the input window.



- Set the **Y Principal plane** and **rotate** the surface by **-10** degrees.
- Generate a **composite curve** for each **end lateral**.
- **Right click** over each **composite curve** in turn and select **Delete Dependencies**.

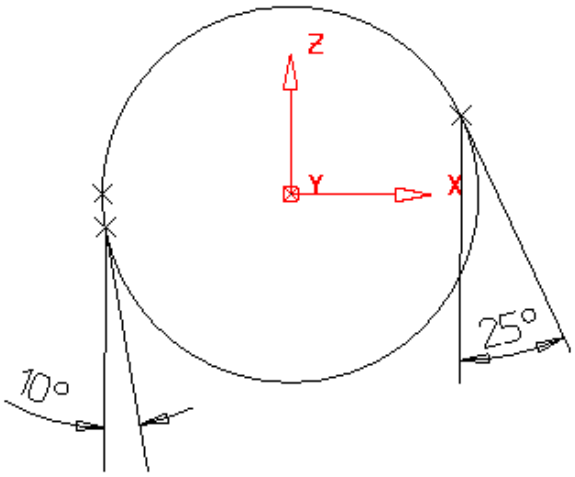
When composite curves are traced from surfaces, the curve remembers the tangency of the underlying surfaces. This means that when a further surface is generated from these composite curves they match perfectly. To remove that relationship, **delete dependencies** is used on the composite curve before a new surface is generated.

- **Create** a **fill-in surface** for **each composite curve**.
- **Delete** the **composite curves** and select the **Z principal plane**.
- **Reverse** any **surface** to have the **gold outside**.
- **Create** a **Convex Fillet** on each end of **Radius 2mm**.



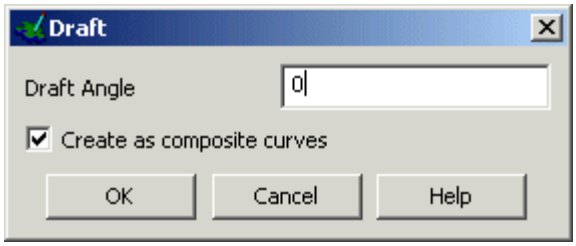
The model is completed and does not lie on the XY plane. Before a split surface can be generated, the natural split has to be found.

It is important to set the active principal plane as it determines the tool draw direction. For a draw along the **Z-axis**, the principal plane must be set to the **Z** plane.



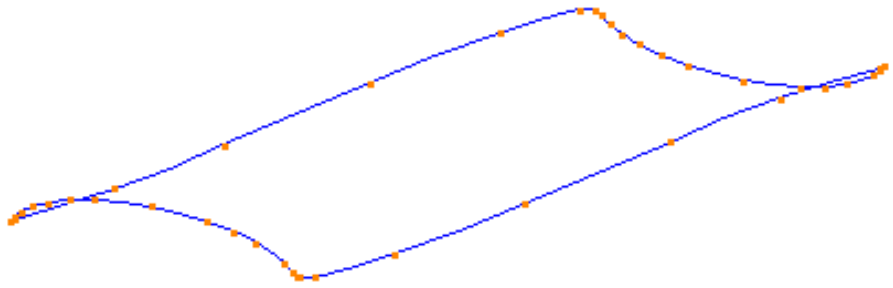
With the draw curve you need to specify the angle of draft required. For an angle of 0 degrees as denoted by a cross it will fall on the sphere's centre line. For a positive angle of 25 degrees then the curve moves up the surface as indicated. For a negative angle of –10 degrees the draft curve moves down the surface.

- Select all **Surfaces**.
- From the **Curve menu** select **Draft Curve**.



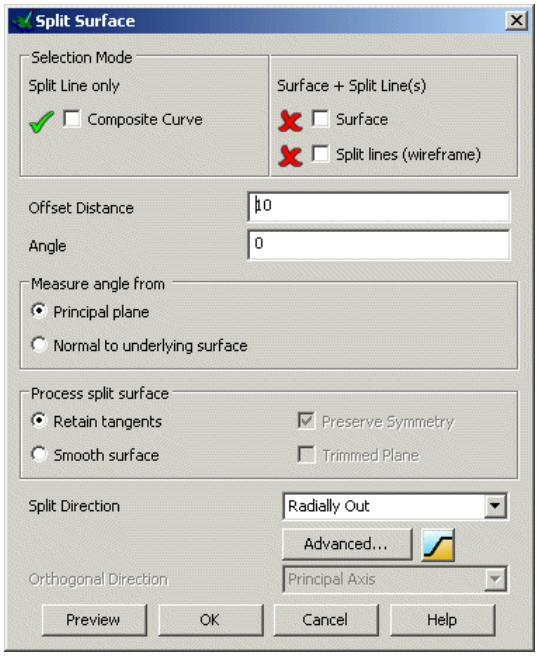
The draft angle is specified in this form. If the composite curve option is ticked PowerMILL Modelling will generate composite curves of the natural draft, otherwise ordinary curves are generated.

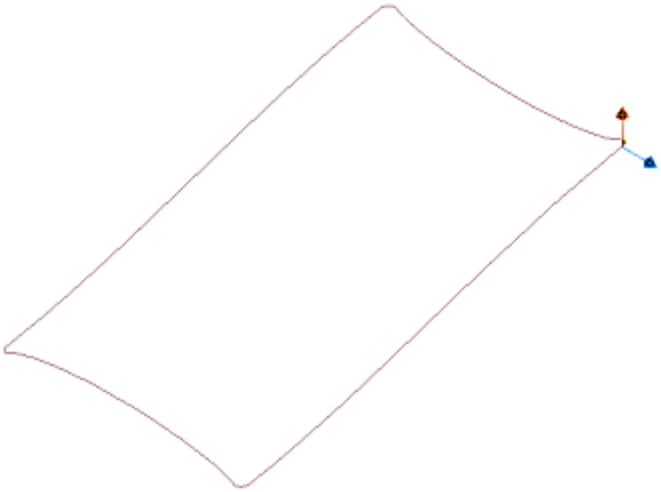
- Enter a **Draft Angle** of **0**, **tick Create Composite curves** and **OK**.
- **Select** the **composite curve** just generated and **Blank Except (Ctrl + K)**.



The split surface can now be created from this composite curve.

- From the **Surfaces menu**, select **Split Surface**.



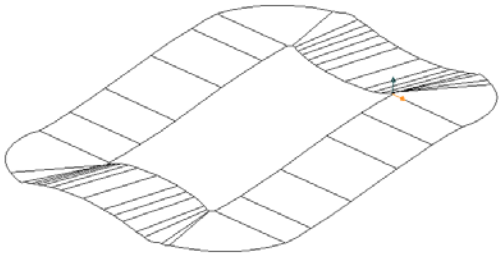


The **Split Surface** form appears and two arrows appear on the split line.
The **blue** arrow indicates where the surface will lie and needs to be pointing outwards from the model. The **brown** arrow indicates the direction of any Draft Angle specified.

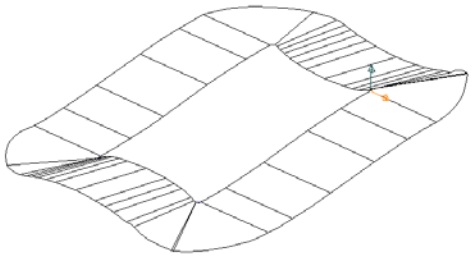
- **Click** on the **arrows** to **change them to as shown, if necessary**.
- **Enter** an **offset** of **40** and select **Preview**.

A split surface is generated with each point from the curve extending tangentially out by a length of 40.

This can cause ripples in the surface and mismatches at the edges.



- Select the **Smooth Surface** option and then press **Preview** and then **OK**.

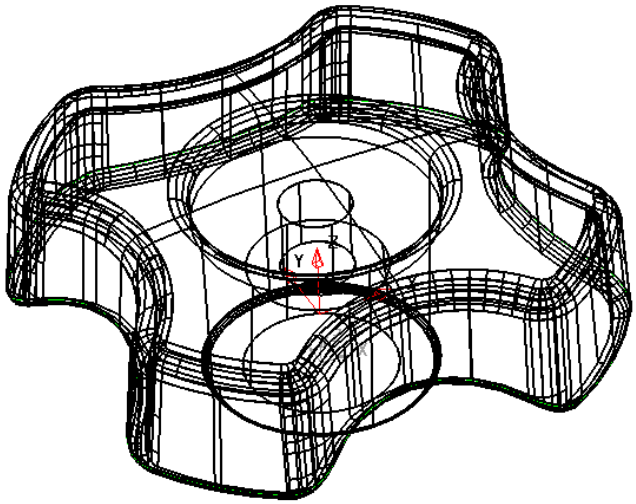


This produces a smoother surface at the edges.

- **Cancel** the form.
- Select **Unblank** and **Delete** the **Surfaces** and **Workplane**.

Split Surface Example

- From the main menu select **File > Import.**
- From **PowerMILL Modelling_data/psmodels_n_dgk,** select '**Split_surf_example.dgk '**.

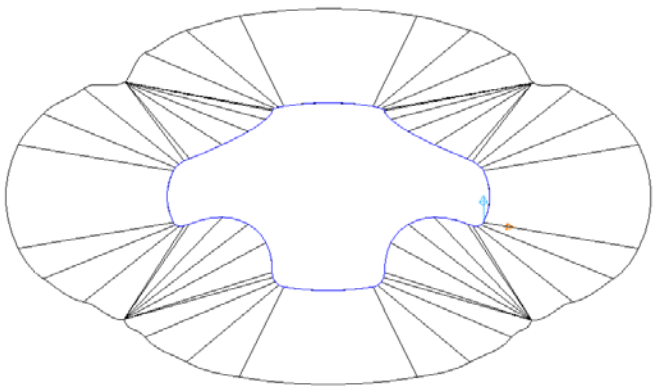


The file contains a surface model and a predefined Composite Curve, which will be used to generate the split surface.

- **Select** the **solid** and then **Blank** (**Ctrl J**).
- Select the **composite curve**.
- From the **surfaces menu** select **split surface**.

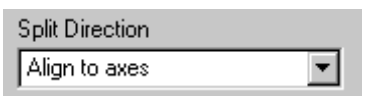
On the Split Surface Form:

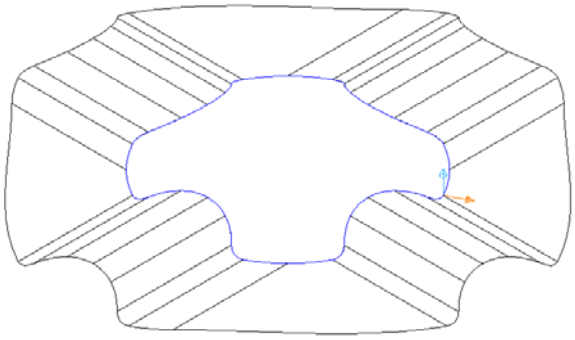
- Enter an **offset distance** of **50** and set the **blue arrow pointing out**
- Set the **split direction** to **Radially Out** and press **Preview**.



This surface is congested around the corners due to the inner corners and the offset length. A way of improving this is to use the Align to Axis option, which will align the split surface to the X or Y-axis.

- **Set** the '**split direction'** option as '**Align to axes'** and press **Preview**.

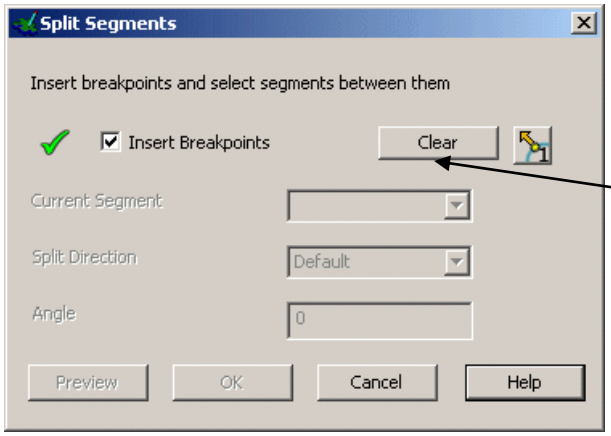




The split surface is now aligned to the X & Y axes giving a smoother surface. Further improvements can be made to the surface by using a combination of radially out and aligned to axes

- Select the **Advanced** option from the form.

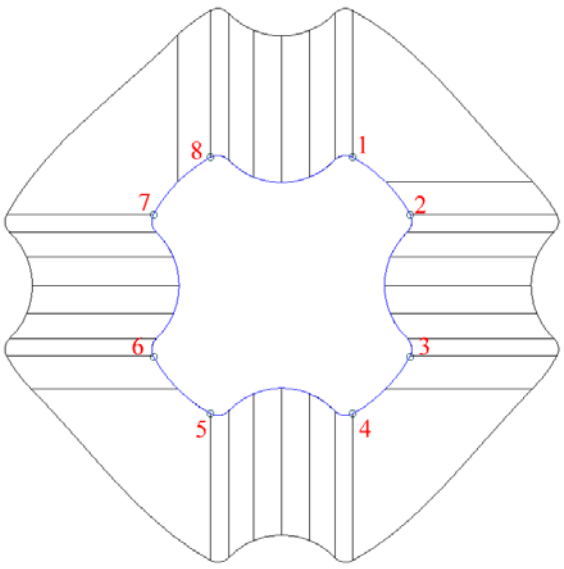
The Split Segments form appears.



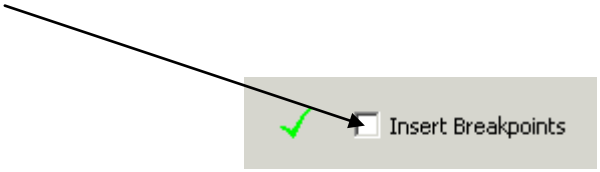
Defining segments for the curve and specifying split direction for each segment can modify Split direction.

- Select **clear** to remove any existing segments from the curve.

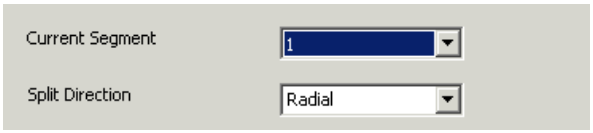
- Using the **mouse click at breakpoints** at the positions indicated.

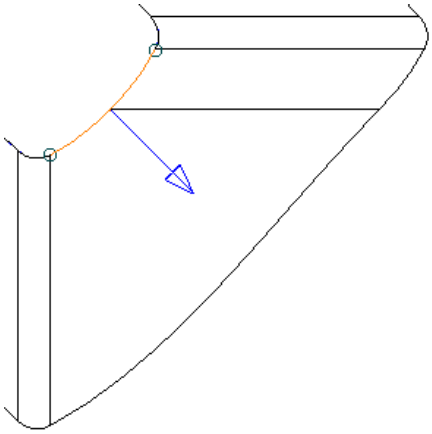


- **Untick** the Insert Breakpoints box to toggle the curve segments option.



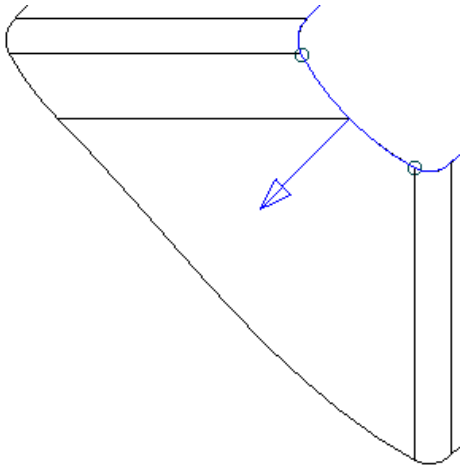
- Select **segment 1** from the dropdown list and set the **direction** to **radial**.





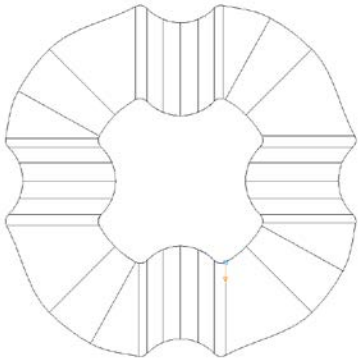
Segment 1 will indicate a radial split.

- Select **segment 3** from the dropdown list and set the **direction** to **radial**.



Segment 3 will indicate a radial split.

- Repeat the process for segments **5** and **7**.
- Select **OK** to close the form.
- Select **Preview** from the **split surface form**.



The **Preview** indicates a combination of radial and align to axis.

Do NOT cancel the form

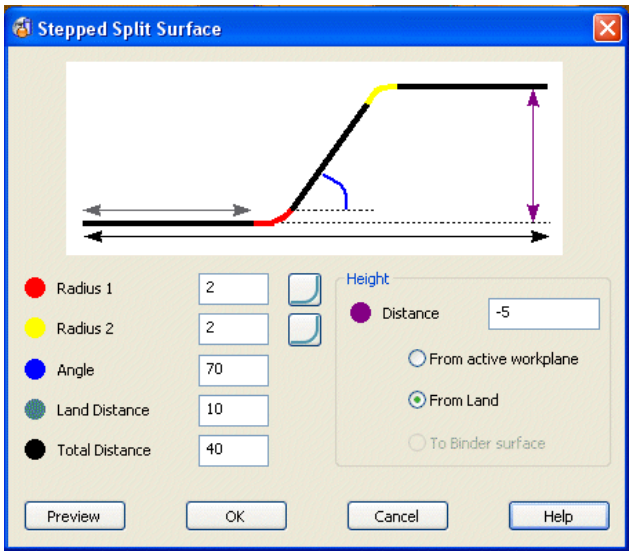
Automatic Stepped Split Surfaces

Stepped split surfaces are used to reduce the amount of bench work needed to ensure correct matching of the two mould halves. Split surfaces can be defined with: -

1. A 'land' distance, which is the length from the outer edge of the part to the 'step'
2. An angle for the step itself.
3. An overall length for the split surface.

In addition the user may specify different radii from the joins between the various segments, or use chamfers.

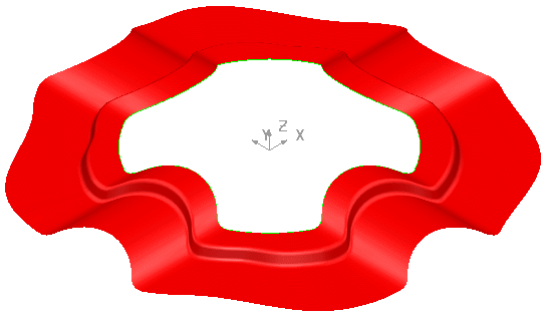
- Select the **Stepped Split Surface option**.



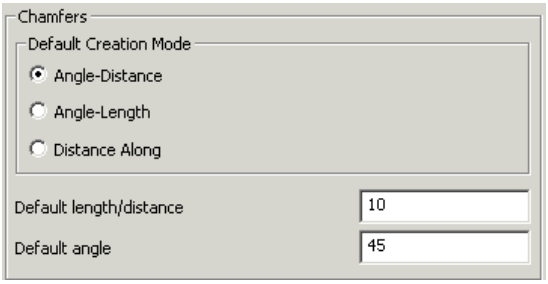
The form allows values to be defined for the stepped split.

- **Enter** the **values** in the form (as shown left) and **press OK**.

The Split Surface is produced with the defined step. A block will be created and trimmed back to the split surface.

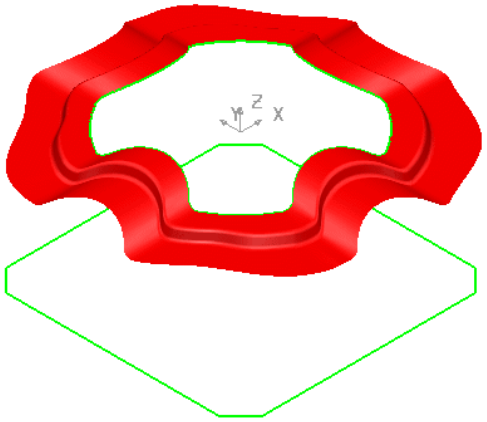


- Create a **Rectangle** from **– 60 -60 -60** of width **120** and length **120**.
- Select **Tools➔ Options, Object** and then **Lines**.



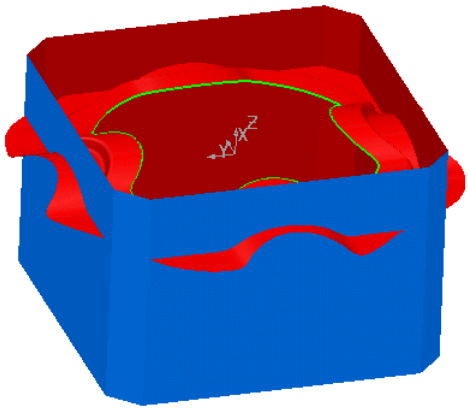
Chamfers are created from the values set in the option form. They can be edited individually but if you have a lot of chamfers to do, then it is easier to change the default setting.

- Set the **Chamfer Distance** to **10** and press **OK**.
- From the **line menu** select **create a chamfer** and click each corner in turn.
- **Generate** a **composite curve**.



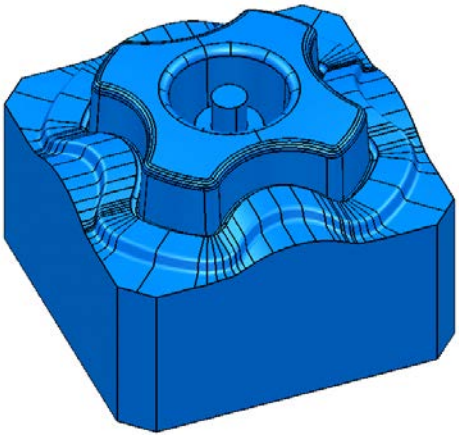
The curve will be used to generate the side walls of the block.

- **Select** the **lower composite curve** and create a **Fill-in surface**.
- **Select** the **composite curve** and create a surface of **Extrusion** with a **Length** of **80**.



The sidewalls need to be trimmed back to the split surface.

- **Limit** the **side walls** to the **split surface**. **Select Unblank** (Ctrl L).



The die block is complete. In the model shown here the handle solid has been split to form the lower die. As an exercise try to reproduce this model.

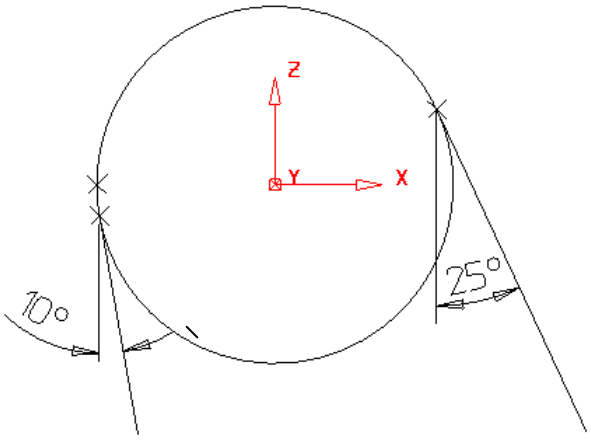
(hint use an copy of the split surface which has been extended)

Generating a split surface does not automatically trim the model. An option has been included in PowerMILL Modelling, (developed as part of PS MoldMaker, which is available as a standard function) called Die Wizard. Using the active solid Die Wizard will automatically split and trim the model creating cavity and core inserts. This will be covered later on in the course.

- Select **File➔ Close** and then **No**.

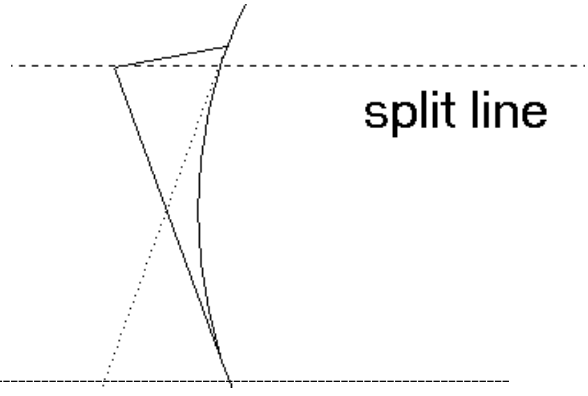
Draft Surfaces

A draft surface can be generated from either a composite curve or a set of surfaces. The draft surfaces are either projected onto the **XY** plane of the current workplane, or onto another pre-selected surface.



The draft surface is generated tangentially from the original surface dependent upon the angle selected, as with the Draft curve command.

Where the split line is generated with an angle above or below 0 degrees, the resultant split surface edges on both the top and bottom may be miss-matched. PowerMILL Modelling increases the lower draft angle so the split surfaces edges match as shown.

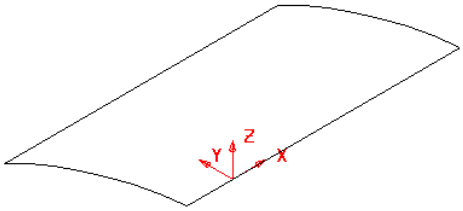


Draft Surfaces from Composite Curves Example

- Select **Create New Model**.
- Create a **workplane** at **0**.
- From the **Arc menu** create a **Three point arc** using the following co-ordinates:

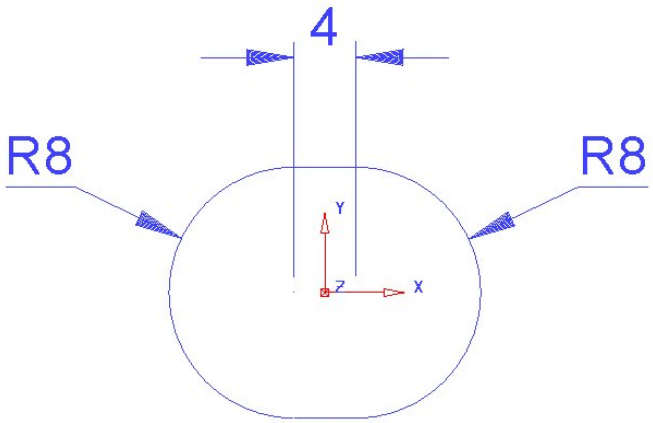
-15 10 4
-15 -10 10
-15 0 8

- Create an **extruded surface** along the **X-axis** of **length** of **50mm**.



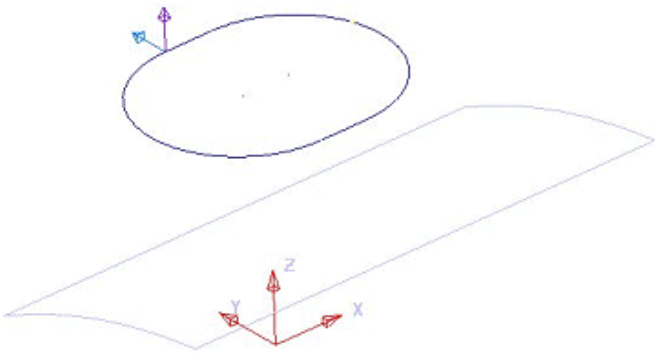
This extruded surface will be used to project a draft surface on, later in this example.

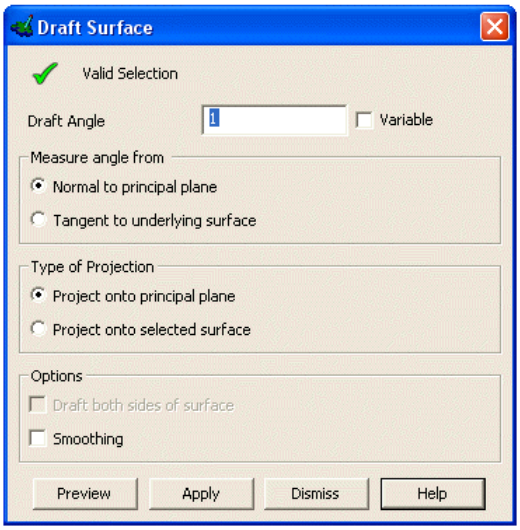
- **Convert** the **surface** (right click over it and select **Convert Surface**).
- **Blank** the **surface** and select a view from the top.
- **Select** the **Z principal plane**.
- Generate the following **wireframe**.



This section will be used to generate a draft surface.

- **Create** a **composite curve** and **Move** up in **Z** by **20mm**.
- **Select Unblank (Ctrl + L)**.
- Ensure the **composite curve** is **selected**.
- From the **Surface menu** select **Draft Surface**.

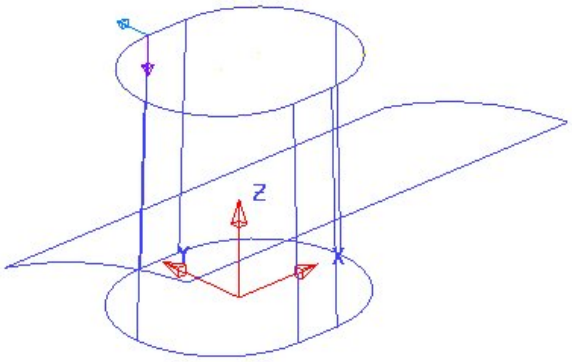




The Draft Surface form appears.

The **Draft Angle** box allows you to specify the taper angle of the surface to be produced. As with split surfaces, the direction in which the surface is created is determined by the two arrows drawn on the composite curve.

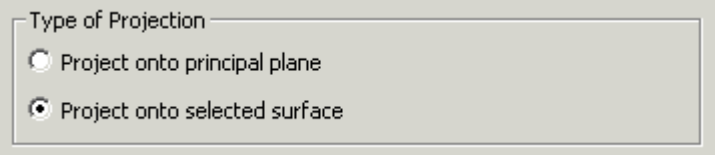
- Set the **Draft Angle** to **2 degrees**.
- Change the **arrows** by clicking on them so they point **down** and **outwards**.
- Select **Preview**.



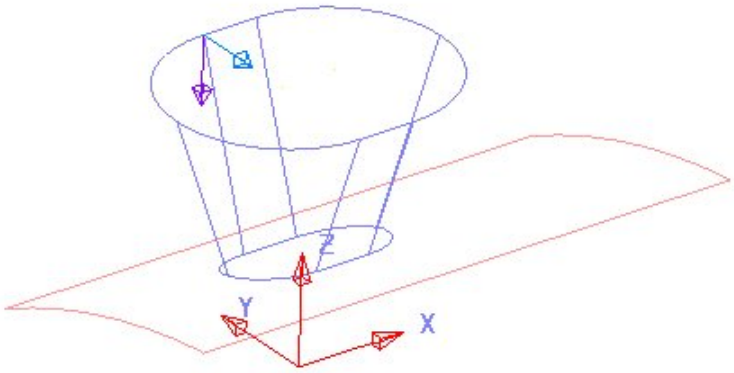
The draft surface is generated and projected onto the **XY** plane of the active workplane.

- **Select** the **extruded surface**.

When selected the surface will appear pink, and the Split Surface option on the Draft Surface form will change to **Project onto Selected Surface**.



- Set the **Draft Angle** to **20 degrees**, and set the projection **arrows** to **inwards** and **downwards**.
- Select **Preview**.



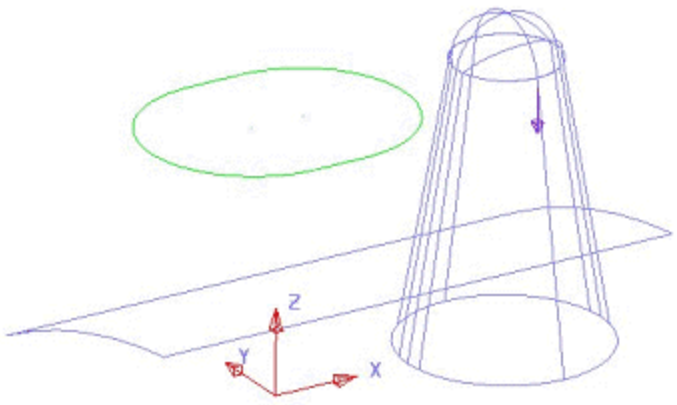
The draft surface is now projected onto the curved surface.

- **Dismiss** the form.

Draft Surfaces from Existing Surfaces

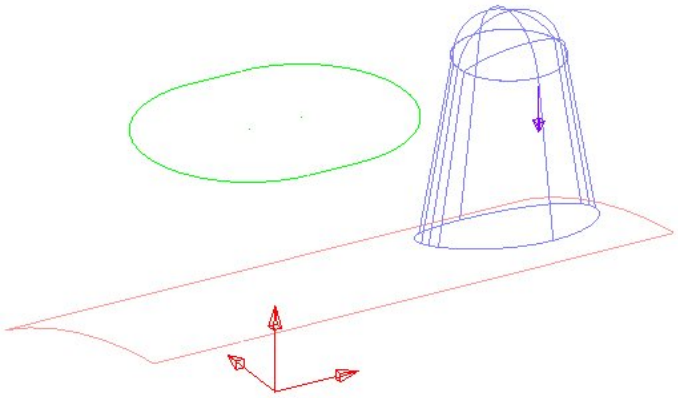
Draft surfaces can be created tangential to existing surfaces.

- Create a **Primitive Sphere** of **radius 4** at **X18 Y0 Z20**.
- Right click over the Sphere and select **Convert Surface**.
- **Select** the **sphere**.
- From the **Surface menu** select **Draft Surface**.
- Enter a **draft angle** of **10 degrees**.
- With the **arrow** pointing **downwards** as shown select **Preview**.



The draft surface that would be produced is displayed.

- Select the **Extruded surface** and then press **Preview**.



A new draft surface that project onto the curved surface is generated.

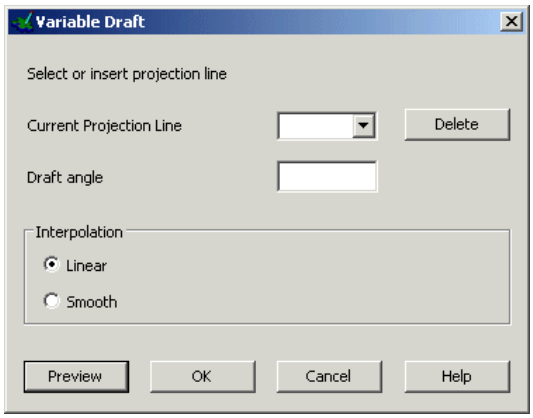
- Select **Apply** and **Dismiss** the form.

Variable Draft

There is the ability to generate a variable draft surface from a selected profile. The variable draft surface may not be always tangential to the original surface, as it has to generate the draft from a fixed defined profile.

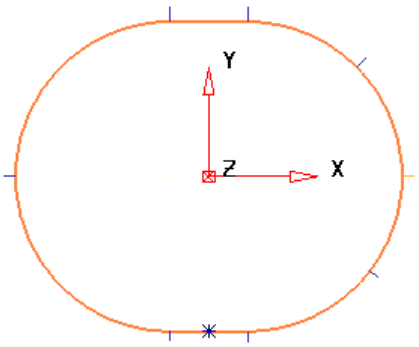
- **Select** the **composite curve**.
- From the **Surface menu** select **Draft Surface**.
- Select the **extruded surface** and make sure that the arrows are pointing **down** and **out.**
- Enter a **Draft Angle** of **3** and tick **Variable**.

- Select **OK**.



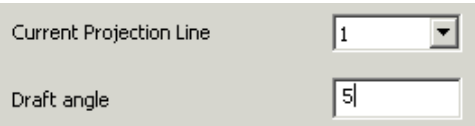
The variable draft form appears. This is an interactive command where lines to display the draft surface are generated by clicking on the draft curve. The draft angle is changed at these lines.

- Select a **View from Top** (down Z).



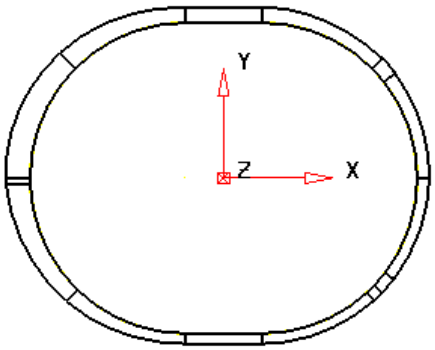
We will create a variable draft of 5 degrees along the sides and 6 degrees around the ends.

- **Click 8 points** around the **draft** curve as shown using the intelligent cursor to snap onto ***End***, ***Key*** and ***Mid Points***.



You can change the draft angle for each of the numbered draft lines on the form.

- Set the **left end projection lines** to **6 degrees**.
- **Select Interpolation** as **Smooth** select **Preview** and **OK**.
- **Dismiss** the form.



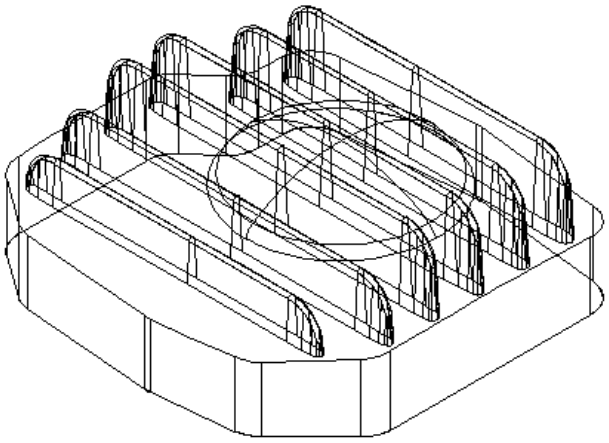
The draft surface is shown.

- **Close** the model without saving.

Pump Project Example….continued

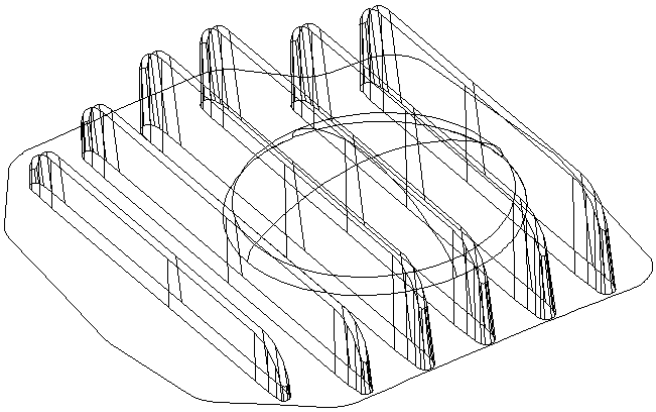
Generate a draft surfaces for each of the ribs and then fillet the model together.

- Open the model **pump-project2**.
- **Blank** all wireframe.
- Select all of the ribs making sure that they all shade gold on the outside and generate a **draft surface** of **3 degrees**.

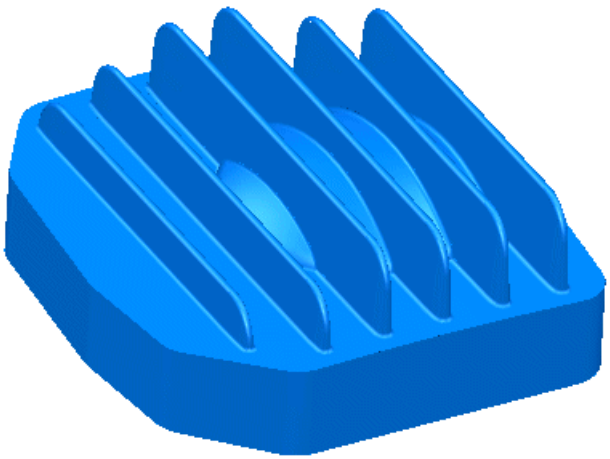


The draft extends to the surface. Fillets can now be generated.

- **Blank Except** the draft surfaces, the dome and the top surface.
- Generate a **fillet radius** of **1 mm** by selecting all the surfaces shown.



- Select **Unblank** and **shade** the finished model.



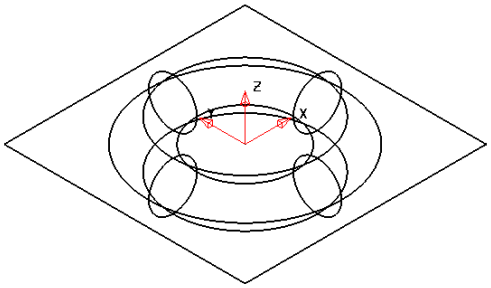
- **Save** and then **Close** the model.

8. Limiting Selection

Limit Surface using a Surface as the Cutting Object

When the **Limit selection** option is applied using **surfaces** they will be trimmed back to their common intersection. The **Next Solution** option enables the user to toggle through all possible, alternative trim combinations. It is possible to select an option to stop the initial selection, **Cutting Object surface** from being trimmed back during the limiting process. When a **surface** has been included in the **Limit selection** process, a **Boundary** is created and only the part of the surface either inside or outside will be displayed. Several surfaces can be limited with a single cutting object.

- elect **Create New Model**.
- Create a **workplane** at **0**.
- Create a **plane primitive surface** at the **workplane** of size **X 50**, **Y 50**.
- Create a **torus primitive surface** at the **workplane** of size **minor radius 5**, **major radius 15**.

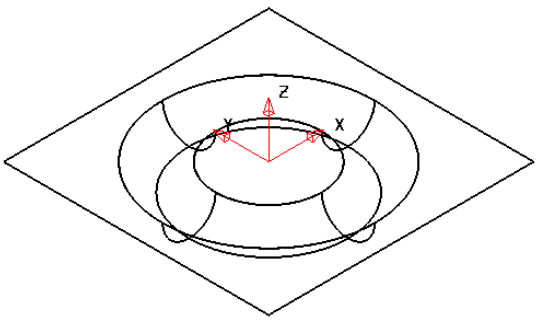


The torus will be limited by the plane.

- Select the **plane surface** (limiting surface). Select the **Edit Toolbar**.
- Select the **Limit selection**.

The limit toolbar appears.

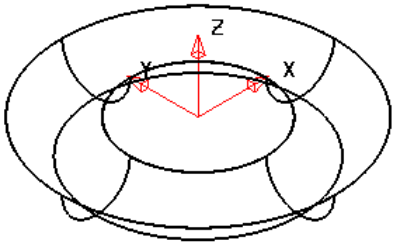
- Select the **torus**.



The **Plane** and **Torus** are automatically trimmed back to their common intersection.

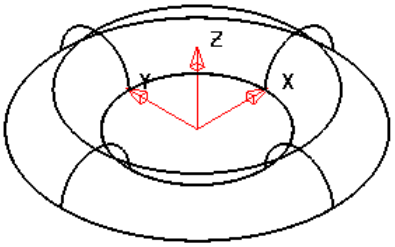
However, this is only one of several trimming options the others being obtained by clicking the **next solution** icon. When the desired option appears, exit the **limit selection** toolbar.

- Select **Next Solution**.



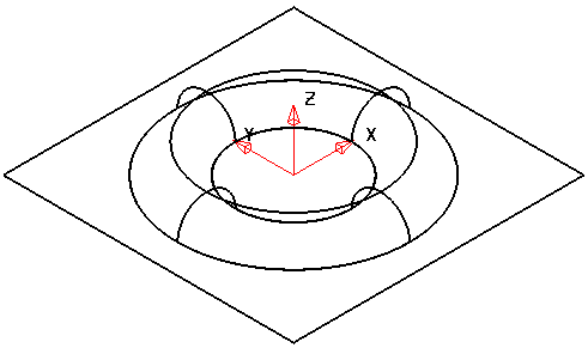
This solution shows the plane limited to a small circle, with the same lower half of the torus.

- Select **Next Solution**.



This solution shows the plane limited to a small circle, with the top part of the torus.

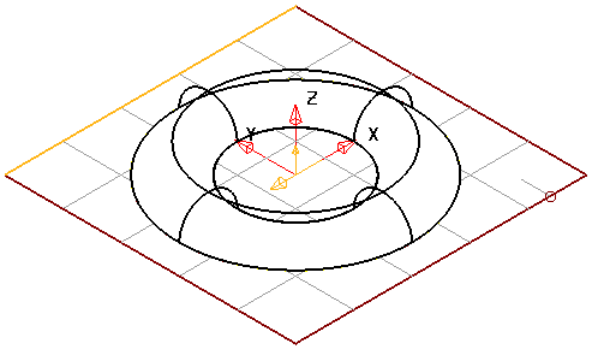
- Select **Next Solution**.



This solution shows the plane with a circular ring limited out and the top part of the torus.

In between pressing the **Next solution** icon the user can dynamically rotate and shade the model to have a better view of the current solution.
The user can continue to toggle through all possible trimming solutions until the required result is achieved.

- **Press Select**.



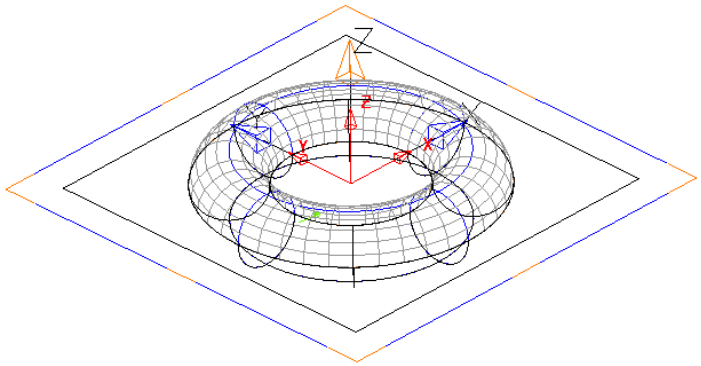
When a single **surface** is selected, then a ***grid*** is displayed within the visible trimmed area of the **surface**.

- Select **Undo**.

- Select the **plane** as the cutting object and then **limit**.
- Select the icon to change to the **keep both** option.

When the **keep both** icon is active, limiting will split the object to be limited into two separate surfaces. This is applied when it is required to keep both halves of a surface such as for the cavity and core.

- Close the **limiting form** and select the **torus**.
- **Press Select**.
- **Select** the **top surface**.

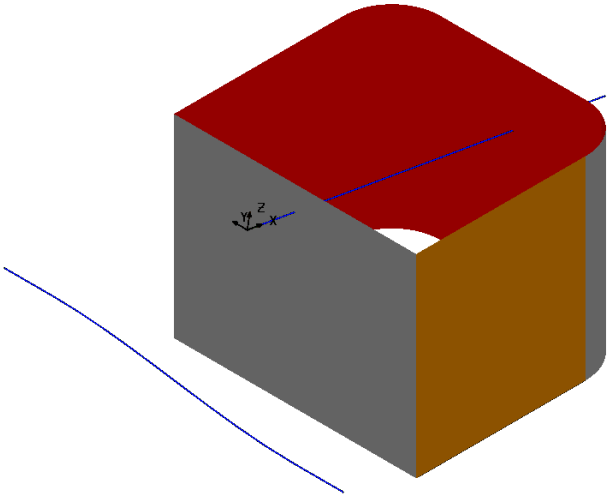


The torus has now been split into two separate upper and lower **surfaces**, with the **surface plane** remaining as one limited surface. A simple copy of the plane can be produced using copy and paste if an additional one was required.

Limit Surface using a Curve as the cutting object

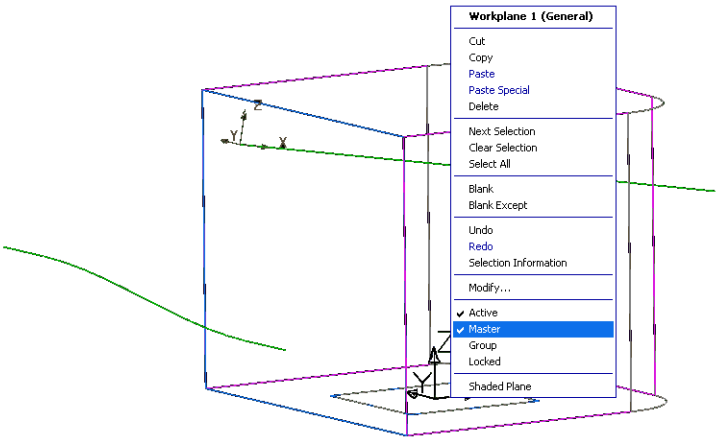
A **Wireframe** geometry entity can also be used as the **Cutting object** as shown in the following example.

- **Close** the existing **model** (no need to **Save** it).
- **Open a** New **model**.
- Select **File - Import** and locate the **wireframe** model:- ***…..\PowerMILL Modelling_Data\psmodels_n_dgk\Limit2.dgk***



The **imported model** consists of a component made up of 6 separated surfaces along with some **wireframe** defining the 2D trimming requirements.

- Right mouse click on the **workplane (1)** located at the base of the component and in the local menu, **tick** both **Active** and **Master**.

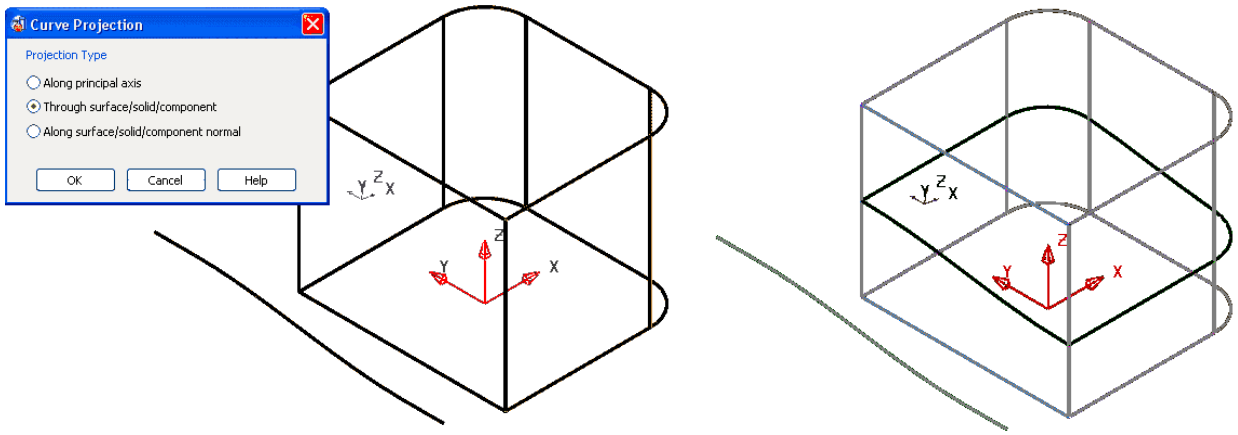


Workplane (1) will default as the **Active** coordinate system if another **workplane** is deactivated.
If a **workplane** is not assigned as the **Master** then the (invisible) ***World*** coordinate system is the default.

- To the lower left of the graphics area Select **X** as the operational axis.

- Pre-Select all **Surfaces** and the **composite curve** aligned on to the left on the above illustration.

- From the **main** toolbar, select **Curve** and then **Curve projection** to open the form as shown below.

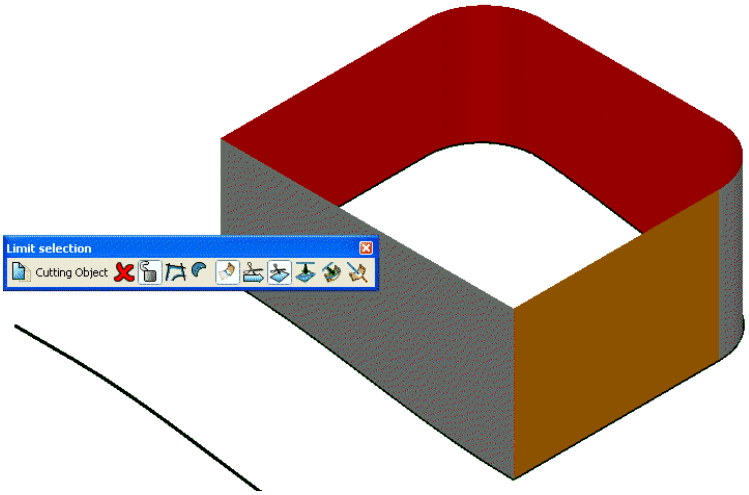


Due to the pre-selection of the **surfaces** and **composite curve**, the form has defaulted with the option ***Through surface/solid/component.***

- Select **OK** to apply the **Curve Projection** option to create the new split, **composite curve** as shown in the above right view.

- To the lower left of the graphics area select **Z** as the operational axis.

- Select the new split line, **composite curve** and then, in **general edits** select the **Limit selection** option.
- Note:-The **curve** is the cutting object.
- Select all the **surfaces** and <u>if required</u>, click **next solution** to produce a trim retaining the parts of the **surfaces** above the split **curve**.



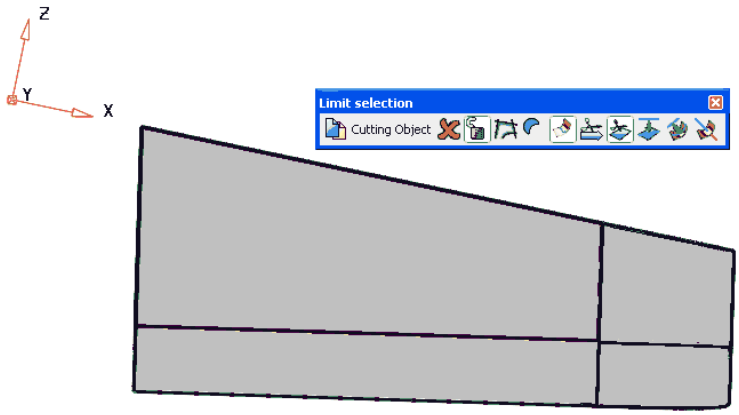
<u>Limit Surface using a Workplane as the cutting object</u>

A **Workplane** can also be used as the **Cutting object** as shown in the following example.

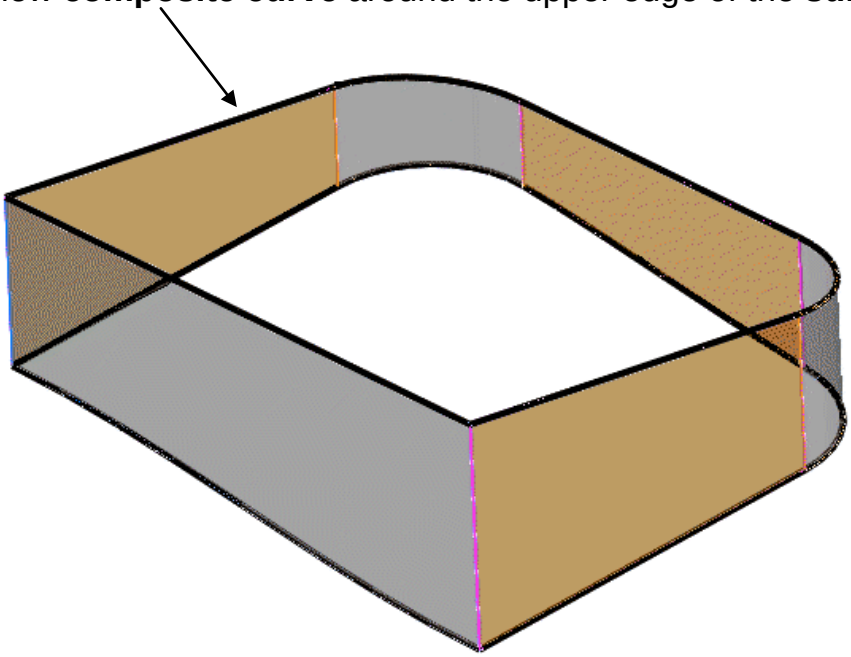
- **Activate** and **select**, **workplane (2)** and in **general edits** select the **Limit selection** option.

Note:-The **workplane** is the cutting object.

- Select all the **surfaces** and <u>if required</u>, click **next solution** to produce a trim retaining the parts of the **surfaces** below the **workplane** (-Z).

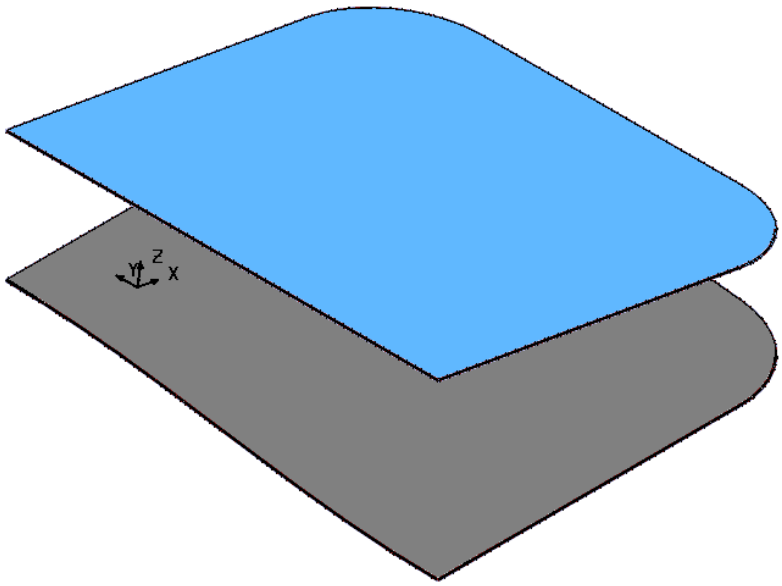


- Close the **limit selection** toolbar by clicking the cross at the top right corner.
- Drive a new **composite curve** around the upper edge of the **surfaces**.



Exercise

- Create a *flat* **Fill-in** surface (***Tangent to surface*** unticked) within the upper **composite curve** and a *3D* **fill-in surface** within the existing lower split, **composite curve**.

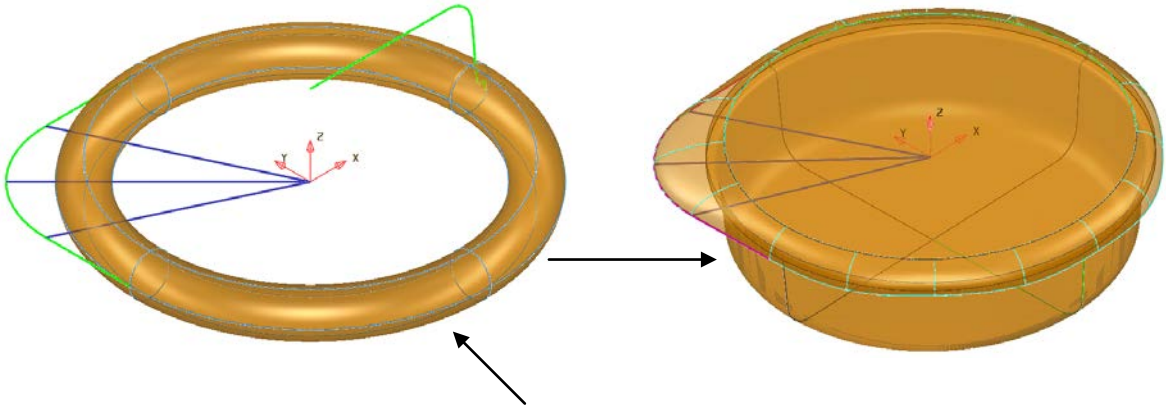


9. Editing Power Surfaces

The following chapter uses a design exercise as the platform to illustrate some of the comprehensive editing options available to **Power Surfaces**.

Food Container Design Example

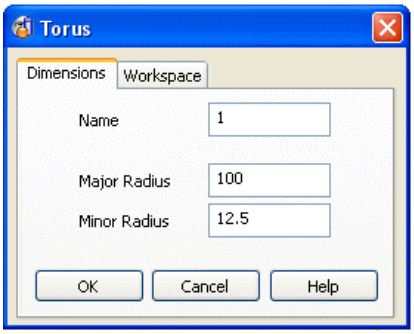
The project will start by importing the model shown below left and will progress to the finished outer form of the food container shown below right.

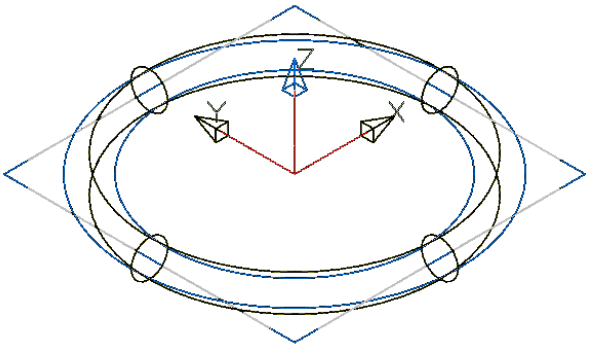


- **Import** the pre-defined CAD data located in**:-…..\PowerMILL Modelling_Data\psmodels_n_dgk\SurfaceEditStart.dgk**
- **Save** the model to:- **D:\users\Coursework\FoodContainer**

Conversion of primitive to Power Surface

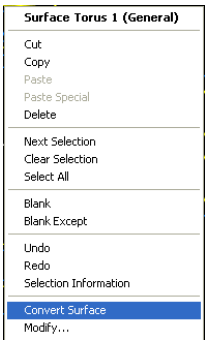
- Right mouse click on the **Primitive Torus Surface** before selecting **Blank Except** in the local menu.

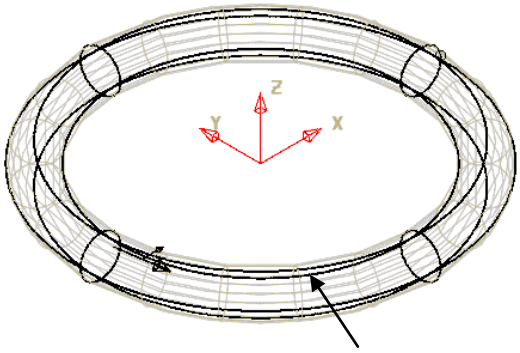




The **surface** is a **primitive** in which an editing form appears in which the options purely apply to the dimensional values of a torus.
Before it is possible to make changes to the actual shape the torus must first be converted to a **Power Surface**.

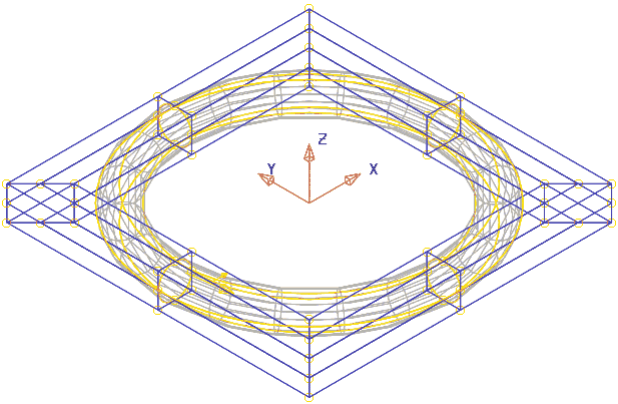
- Right mouse click on the **surface** again and in the local menu select **convert surface**.



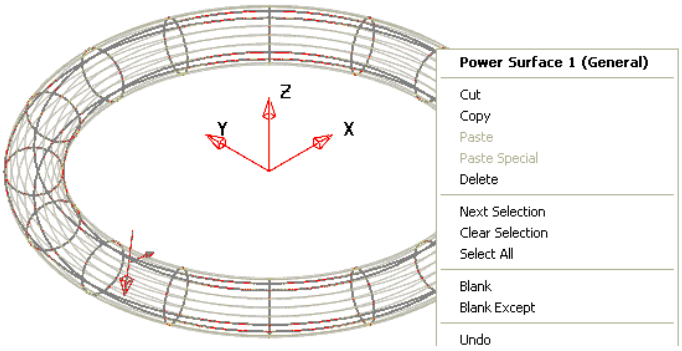


Depending on the settings the surface will either convert to a **NURBS surface** (default) or directly to a **Power Surface**.

NURBS surfaces still exhibit limited editing capability but are more effective at initially defining awkward shapes, which explains why they are applied as the default option. If a **NURBS surface** is selected with the right mouse and **modify** selected in the local menu the above **toolbar** appears and a framework appears around the surface. Note the fact that only a few of the editing options are available (not greyed out!) in the **toolbar**.



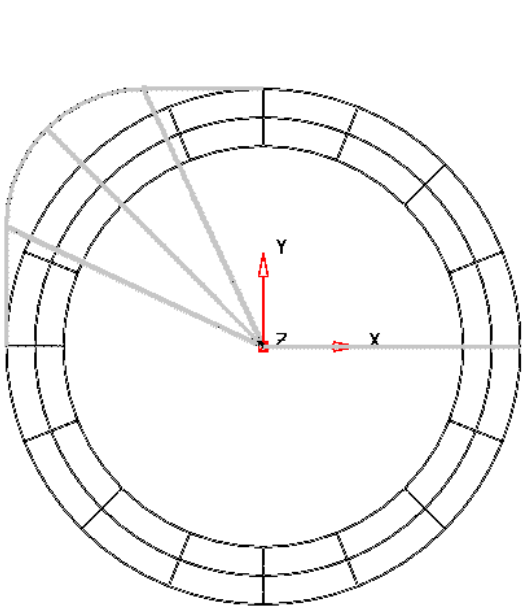
- Right mouse click on the **surface** again and in the local menu select **Convert Surface**.

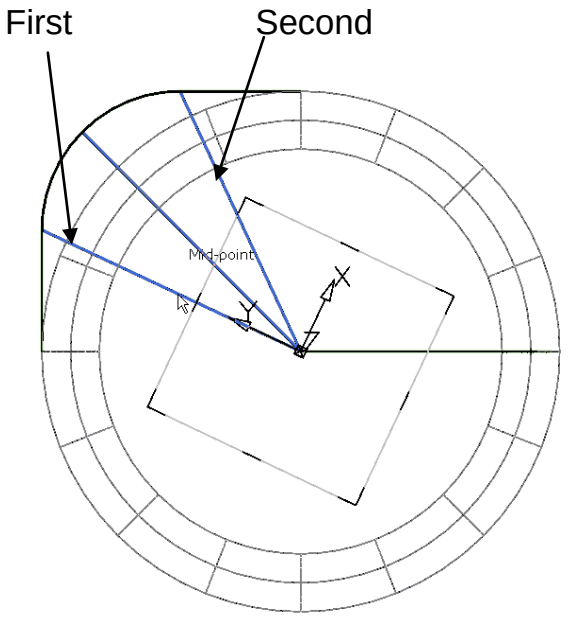


The **NURBS** surface will be converted to a **Power Surface**. Note the fact that this time all of the surface editing, options are active in the **toolbar**.

- Select a **View From Top**.

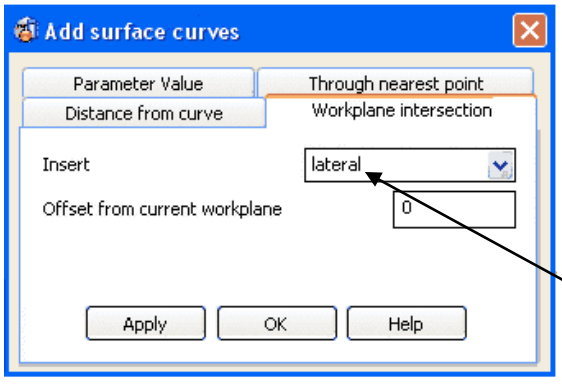
Dynamic editing of a surface curve





Two additional **surface curves** are to be added aligned to the end points of the fillet radius along the route of the lip (as identified on the ***First*** and ***Second*** construction lines). Any original **surface curves** not aligned to key points on the lip form in this area will then be deleted.

- Select the **Workplane** and ***dynamically*** rotate it to align the **Y Axis** with the first of the construction lines that run from the centre to the ends of the radius on the modified corner geometry.
- Set the operational direction to and make sure that the **Workplane** is **Active**.
- Quickly double left mouse click the **Power Surface** to open the **surface/curve** editing toolbar.
- Select one of the cross sectional, **surface curves** followed by the **Add curve** option to open the following form.

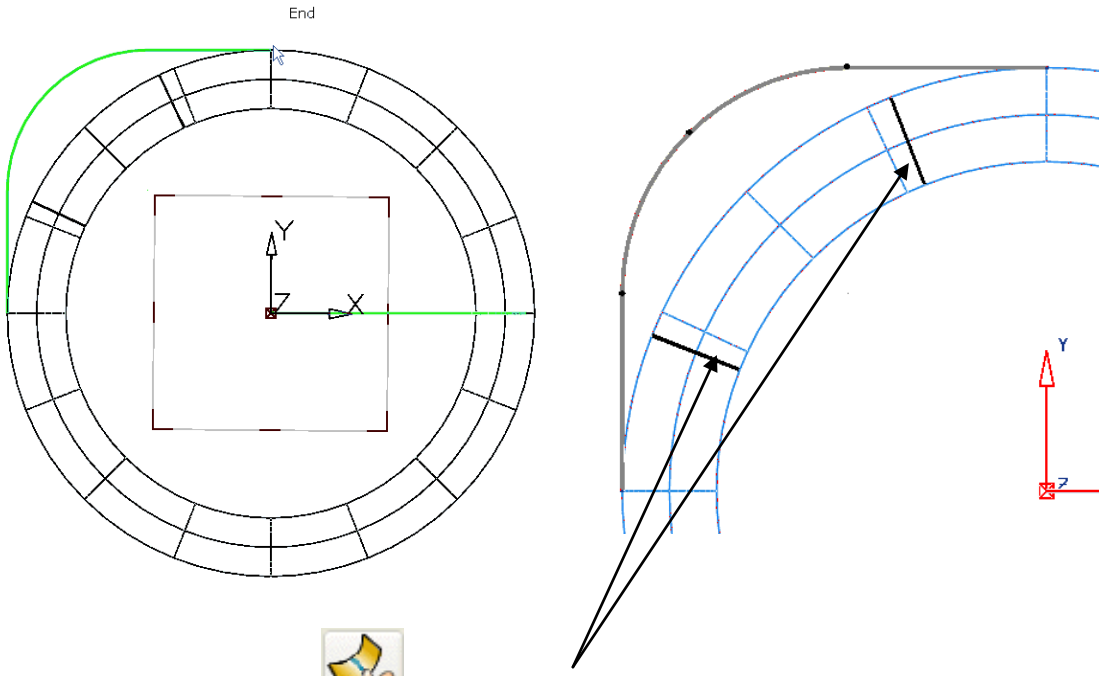


- In the ***Add surface curves*** form select **Workplane intersection**.

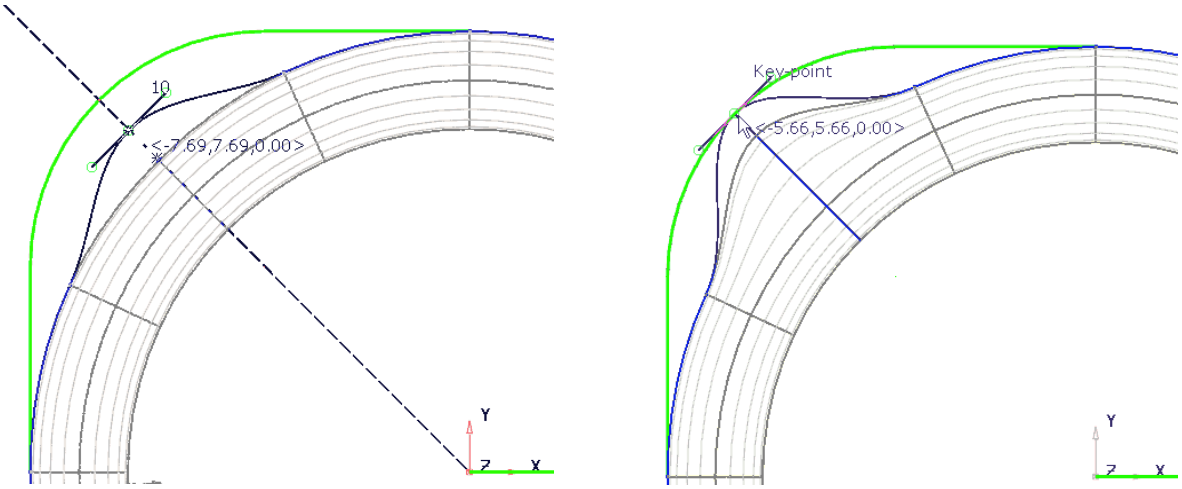
By selecting a cross sectional, surface curve prior to opening the form the ***Insert*** option has preset to **Lateral**.

- Select **Apply** to insert an additional lateral flush with the **workplane** YZ plane.
- ***Dynamically*** rotate the **workplane** to align the **Y Axis** with second of the construction lines that run from the centre to the ends of the radius on the modified corner geometry.
- Insert a second additional **Lateral** flush with the **workplane YZ** plane.

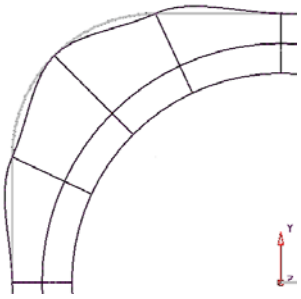
Surface/Curve editing toolbar

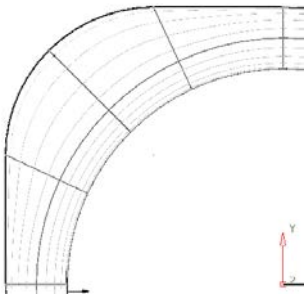


- Select and **Delete** the 2 **laterals** that are not aligned to **key points** on the lip form **composite curve**.
- Select the middle surface point on the outer longitudinal in the top right quadrant and **drag** it to the corresponding point on the new lip form **composite curve** (as shown below).



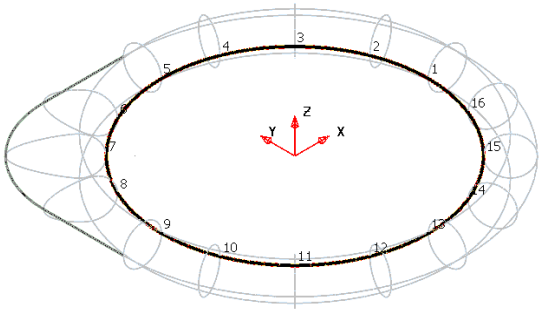
- Repeat the **Drag Move** process on the adjacent surface points to create the following (Note the **tangency** and **magnitude** through the three points requires freeing up to achieve the most natural alignment).



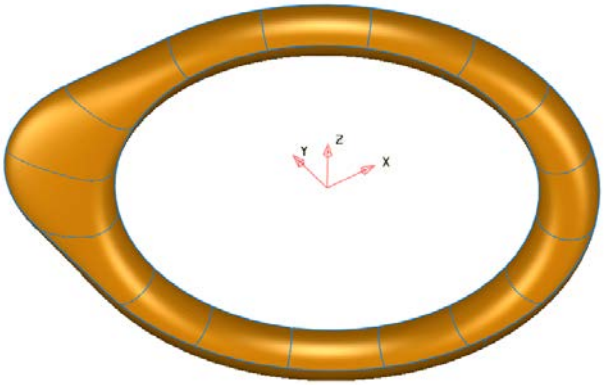


- Select the **longitudinal** followed by the three **points** (***Shift Select***) through which correct alignment is required.
- Right mouse click on the **longitudinal** and in the local menu select **Free tangents and magnitudes** (This creates the most natural geometric flow through the selected **surface points** taking into account the adjacent non selected points).

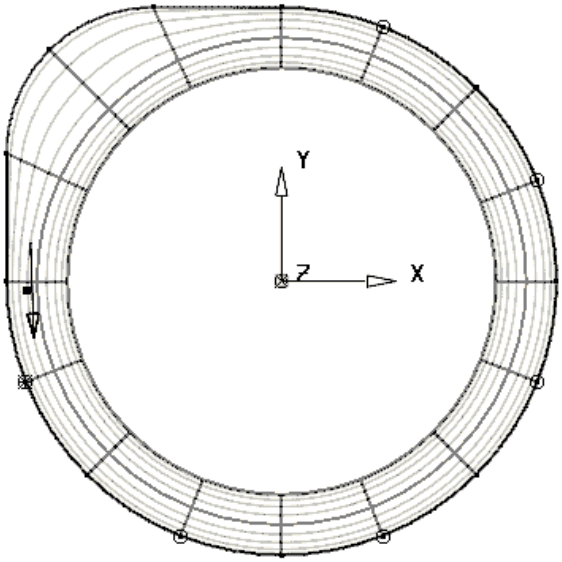
- Select the **longitudinal** running around the inside of the rim.



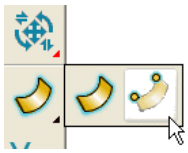
- In the **surfaces/curves editing** toolbar select **Break surface** to split it into 2 separate upper and lower halves.
- Select and **Delete** the upper half, **surface**.



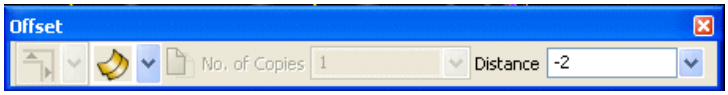
- Select a **view from top** (down Z) and select the alternate 6 surface points around the outside of the lid as marked below.

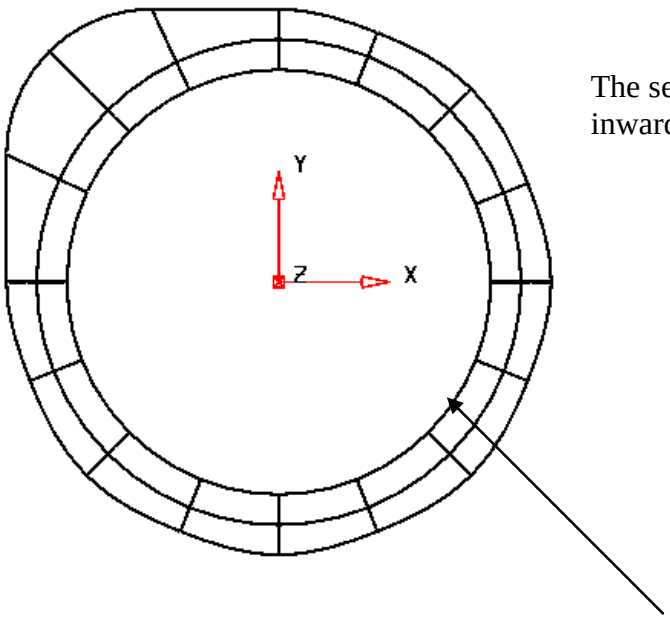


If one or more **surface curves** or **surface points** are selected it is possible to select an **Edit Sub-Item** option. This will cause the **General Edit** options to apply to the selected sub items and not the **surface** as a whole.



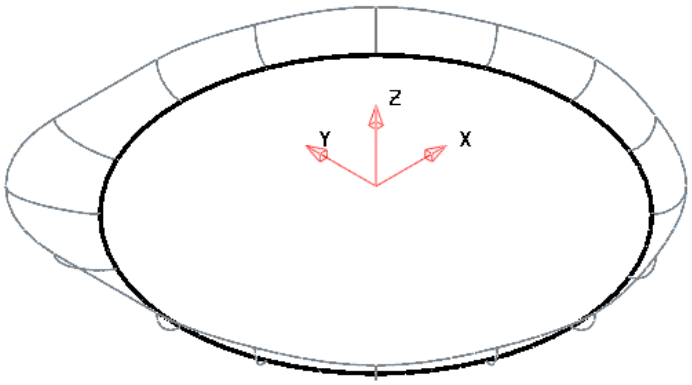
- Select the general edit options and click the **edit sub-item** icon.
- Select the **Offset** option and input a value **–2** before clicking the Return key.



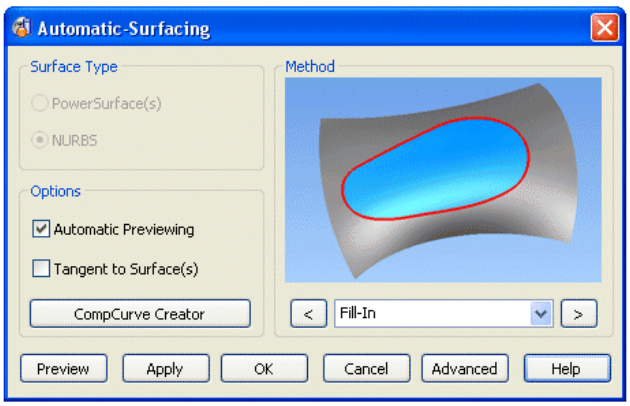


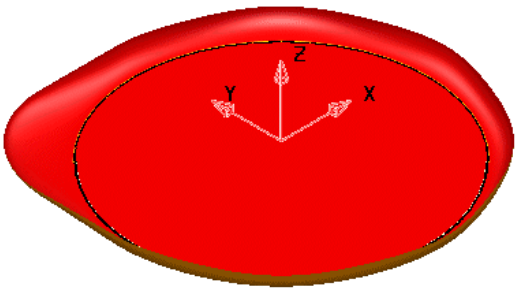
The selected **surface points** have offset inwards normal to the **surface**.

- Select and **Delete** the current, inner most **surface curve**.
- Create a **Composite curve** along the new, inner most **surface curve**.

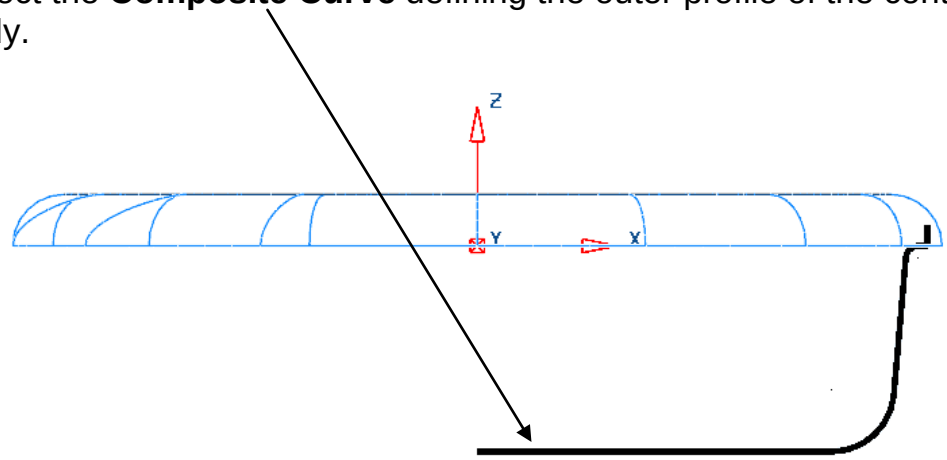


- With the **curve** selected open the **Automatic Surfacing** wizard, which in this case will pre-select the **Fill-In** option.



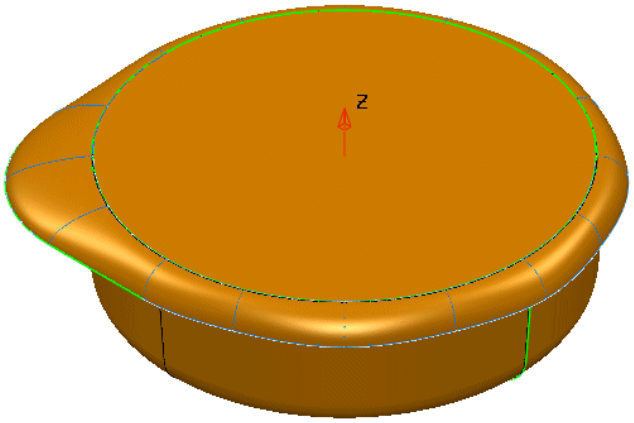


- Select **Apply** to accept the new **Fill-in surface** and then select **OK** to close the form.
- Rotate the **Workplane** 180 degrees about the **X Axis** and select a view along **Y**.
- Select the **Composite Curve** defining the outer profile of the container body.



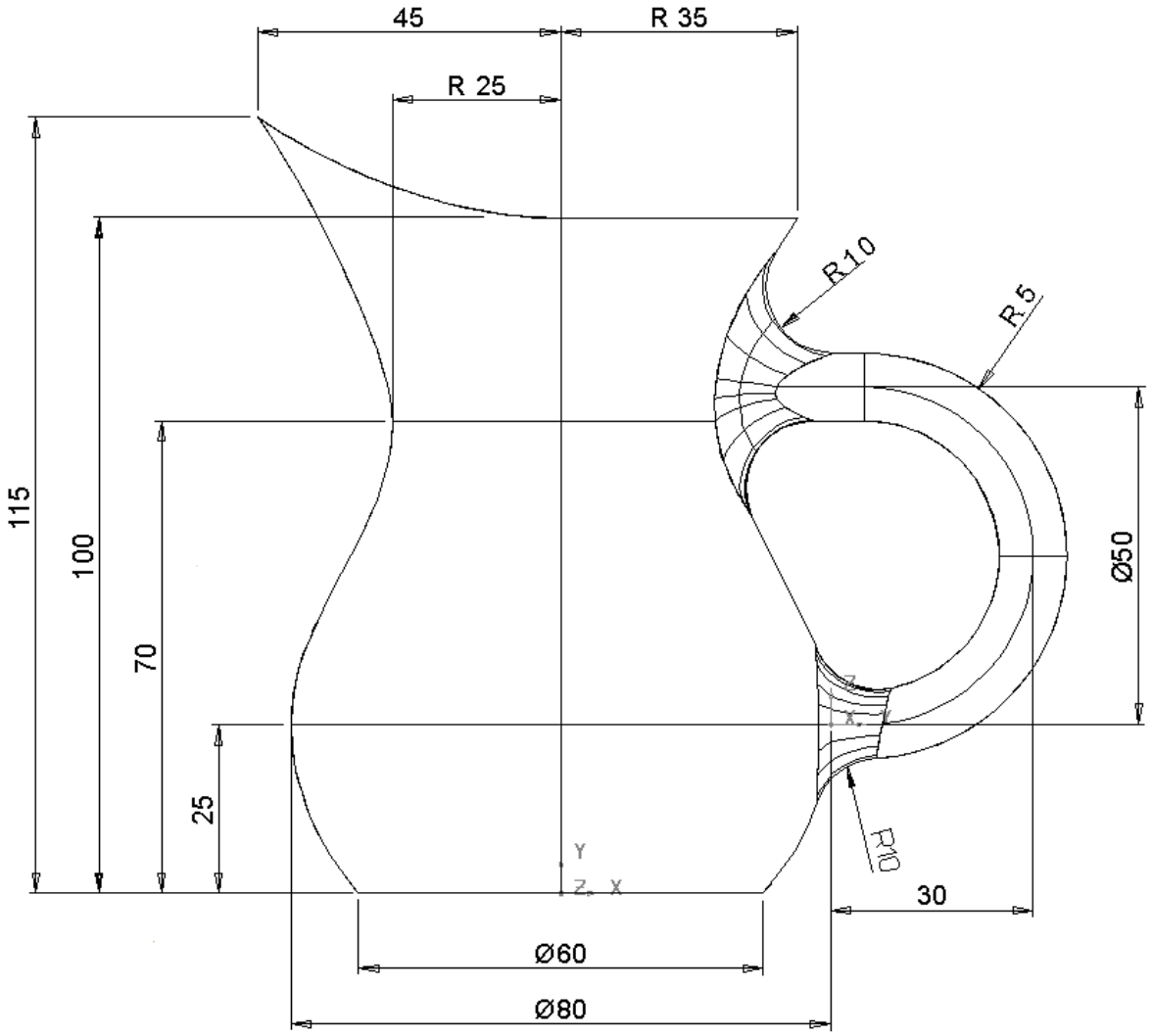
- Select the, create a **Surface of Revolution** option.

- Select an **Iso 1** view to display the following food container design, outer form.



Jug Exercise

- Create a Surface model of the **jug** as shown dimensioned below and save as **D:\Users\Coursework\my-jug**.



10. Boundaries and Pcurves

Parameter Curves and Boundaries

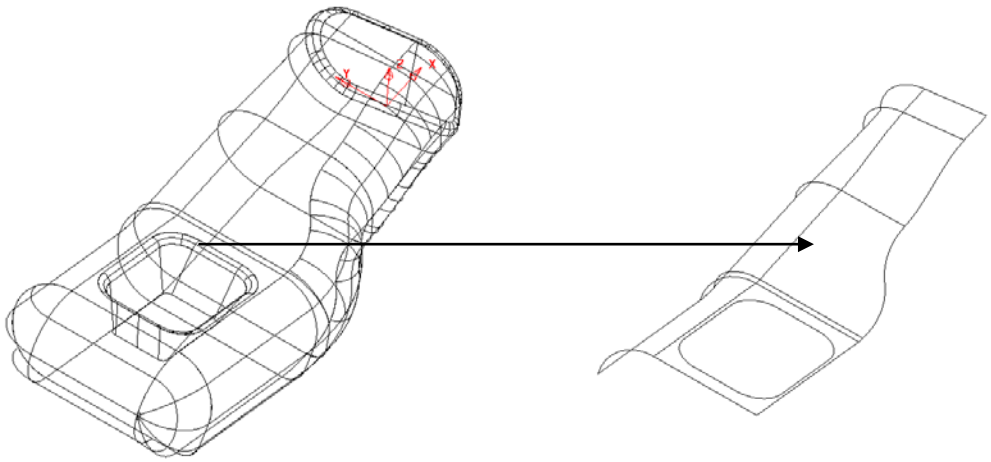
Parameter curves (**pcurves**) are defined along points (**ppoints)** that lie on a surface. They are created automatically, by default during surface limiting or filleting. They can also be generated manually by projection of wireframe entities onto a surface. As moves between **ppoints** are linear, any curvature is controlled by the proximity of adjacent **ppoints** within the tolerance setting.

Boundaries are generated along the **pcurve** network to define trimmed areas on a surface.

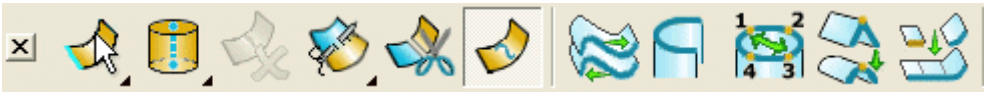
Individual **pcurves** and **boundaries** are unique to a **Surface** and can only be accessed by opening the **Trim Region Editing**, toolbar (**Right** click on a surface for menu options or alternatively access directly from the **Surface Edits** toolbar).

Definition of Boundaries

- **Import** the model **m0_switch_housing.psmodel** from **PowerMILL Modelling_data.**
- **Select** the **upper surface** (as shown below) and apply **Blank Except**.

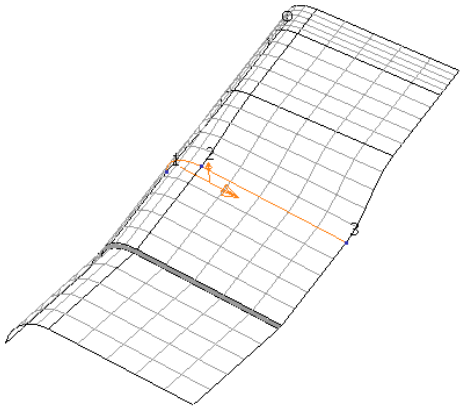


- **Select** the **surface** to open the **Surface Edits** toolbar.



The Turn Trimming On/Off icon toggles surface trimming for the selected surface(s). It is switched on (pressed in) by default for all surfaces.

- Turn **Trimming** off with **Turn Trimming On/Off**.

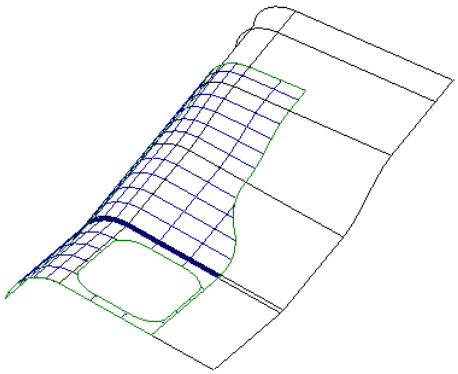


The surface is displayed without trimming it is possible on occasions for an imported surface to enter the model with the trimming switched off making it appear that information is missing. If this is the case, switching the icon will correctly display the trimmed surface.

- Select **Trimming On/Off** to switch the trimming back on.
- **Right Click** on the surface and select **Surface Trim Region Editing.**

The **Trim Region Editing** toolbar appears. This has two modes, **Boundary Edits** and **Pcurve Edits**. The user can switch between modes using the pull down menu to the extreme left of the toobar.

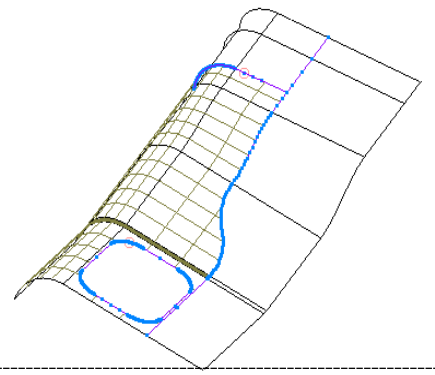
- Select **Boundary Edit Mode.**



The whole surface is displayed with the trimmed area identified by a mesh of grey detail lines. All existing **boundaries** are displayed marking the edge of the surface area that is trimmed. The **pcurves** are not displayed in this mode.

If a **boundary** is removed from a surface the associated **pcurves** remain but are no longer involved in the trimming process.

- Select **Pcurve Edit Mode.**

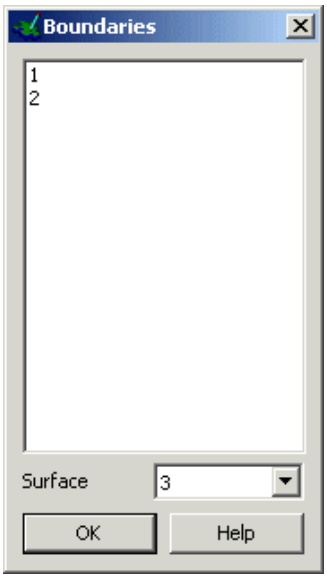


The **pcurves** are shown along with trimmed areas. The actual **Boundaries** are not displayed in this mode.

If a **pcurve** is deleted from a surface any associated **boundary** will also be removed.

Note: not all routes defined by **pcurves** are necessarily included in the **boundary** definition.

- Select **Boundary Edit Mode** then the **Boundary Selector** .



When a **boundary** is selected it will change colour.

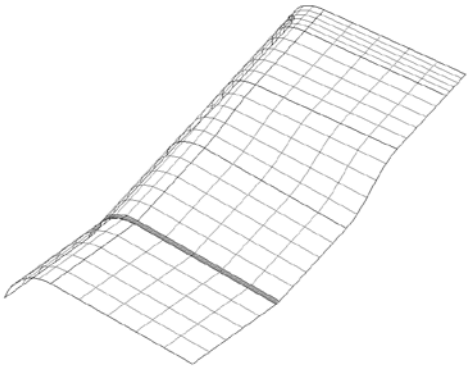
The **boundaries** used to define the trimming of the selected surface are listed here. A **boundary** can be selected by highlighting it's number. Several **boundaries** can be multi-selected by holding down the **shift** key.

The use of the **Crtl** key will enable listed **boundaries** to be individually selected or deselected.

A **boundary** can also be directly selected from within the graphics area with a left mouse click.

Note: Trimming will only occur if a **boundary** forms a closed loop.

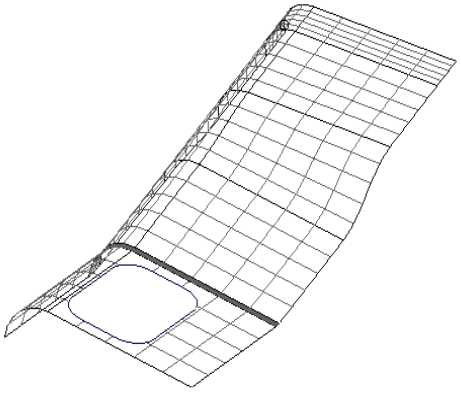
- **Select** both **boundaries** by selecting with the **shift key** depressed.
- **Select OK** and then select **Explode.**



With the **boundaries** exploded the trimming is removed, showing the full surface area. The **pcurves** remain intact but are no longer in use as part of a **boundary** definition.

The **pcurves** still exist and can be made visible by toggling into **Pcurve Edits**.

- Select **Autocreate** and the partially trimmed model appears as shown below.



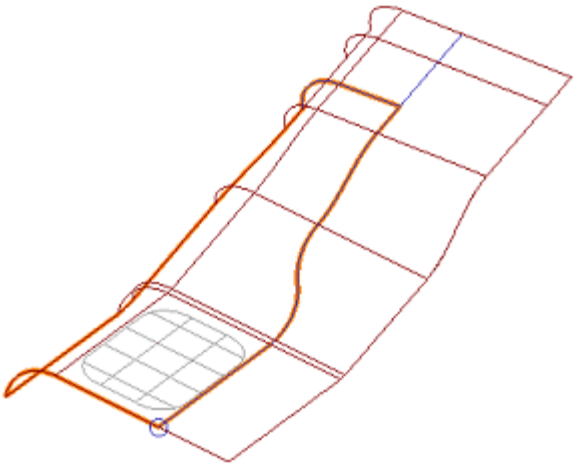
Part of the required **boundary** has failed to appear. This is due to there being a branch point along the network of **pcurves** making it impossible for the software to determine which route to take.

The easiest way to create the required trim option is to manually define the route around the **pcurve** network as shown in the next section.

- Select **Recreate** to open the toolbar and display all unused **pcurves** on the surface.

The create trim boundary toolbar appears and this is used to trace along the pcurves to define a boundary. It is similar to the composite curve toolbar.

All of the pcurves are drawn on the surface so they can be selected. To make a boundary the pcurve track needs to be closed and you can trace along the edge of a surface or a curve to achieve this.

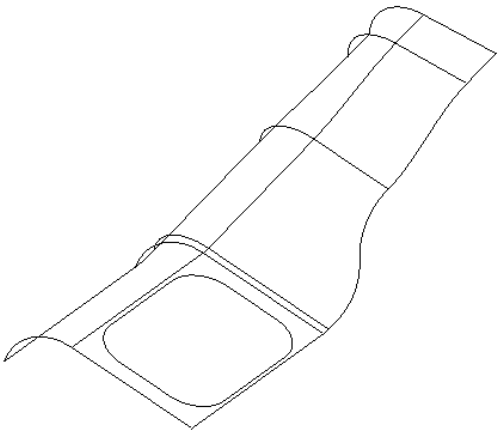


- Select the **first pcurve** and **follow around** to produce a closed shape.

As the pcurve is selected, it is highlighted.

- Click **Save** and **Eject**.
- **Deselect** the **surface**.

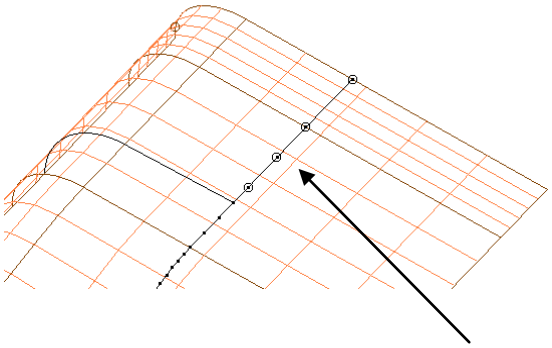
By de-selecting the surface, the finished, trimmed surface can be seen.



The next stage is basically a repeat of the above, but this time removing excess **pcurve** data to enable **Autocreate** to create the required **boundaries** automatically.

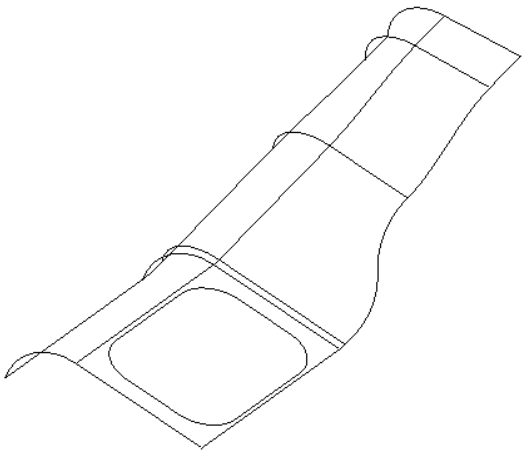
- **Select** the **surface**.
- **Select** the two boundaries.
- **Press Explode.**

- Select **Pcurve Edit Mode.**
- Select the **long pcurve** along the part not required for **boundary** definition.



When a pcurve is selected the ppoints are displayed. These can be selected and deleted, thereby altering the pcurve.

- **Shift-select** the four extra **ppoints.**
- Click the **Delete Point.**
- Select **Boundary Edit Mode** followed by **Autocreate.**
- **Deselect** the **surface**.

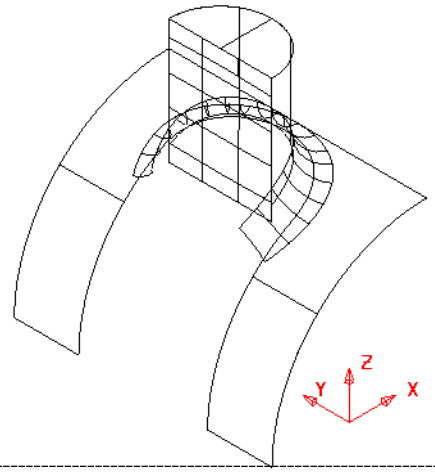


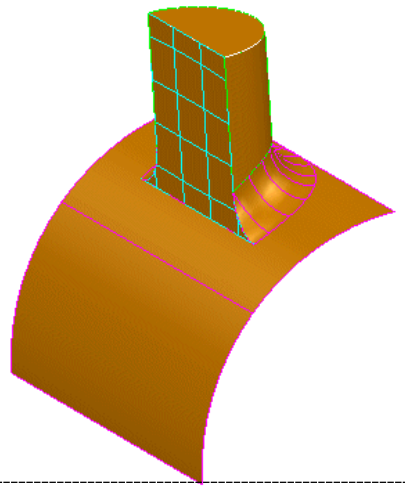
As a result of removing the unused **ppoints** future automatic, trimming operations will immediately produce the desired results and not stray along a path defined by redundant **pcurve** data.

- Select **File➔ Close** and then **Yes**.

Fixing Incorrectly Trimmed Surfaces

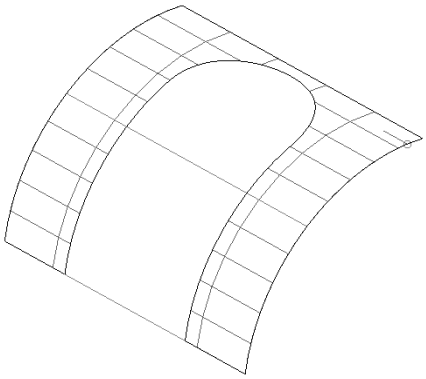
- **Import** the model **locationlug**.**psmodel** from **PowerMILL Modelling_data.**





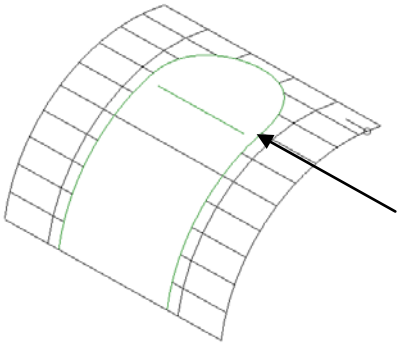
The imported model shown includes several incorrectly trimmed surfaces requiring a combination of **Pcurve** and **Boundary** editing to correct the faults.
The more complex the network of **pcurves** on a surface, the less likely are the chances of obtaining the desired trim options automatically. The following worked example takes the user through typical stages of **pcurve** and **boundary** editing to produce the correctly trimmed model shown above right.

- **Select** the **curved, base surface** and select **Blank Except (Ctrl + K).**
- **Right click** the surface and **select Trim Region Editing.**
- Select **Boundary Edit Mode** and **Boundary Selector**.



The boundary is drawn on the surface. This is incorrect and needs deleting.

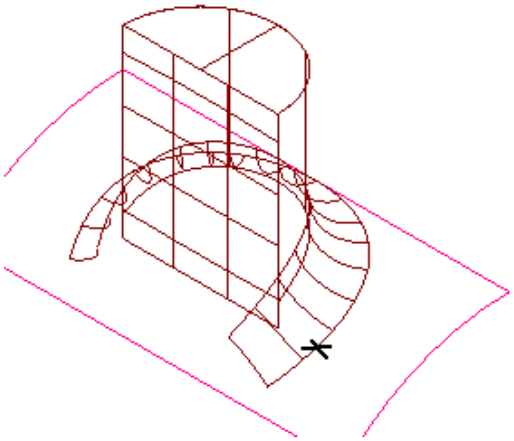
- In the form select **boundary 1** and press **OK**.
- **Select Explode.**
- Select **Pcurve Edits**.



The surface contains two **pcurves**. One is correctly defining the intersection with the vertical face of the location lug.

The other, U-shaped pcurve is defining the path of an old fillet prior to an amendment, and needs to be deleted.

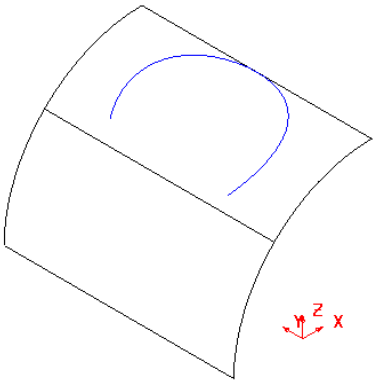
- **Select** the **'U' shaped pcurve** and select **Delete a p-curve.**
- **Select Unblank** (Ctrl L).



With the surfaces displayed, a composite curve can be created from the lower edge of the fillet.

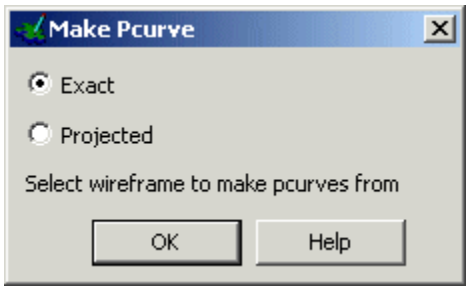
This new composite curve will then be turned into a pcurve.

- **Create** a **composite curve** by using **ALT + left mouse button** on the lower side of the **fillet** surface.
- **Blank all** apart from the **composite curve** and the **curved surface**.



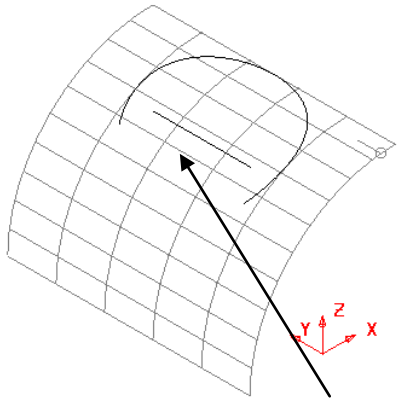
The composite curve and the surface is shown. The composite curve is made into a pcurve by projecting it onto the surface.

- Select the **lower curved surface** and select **P-curve Edit Mode**.
- Select **make pcurves from projecting wireframe**.



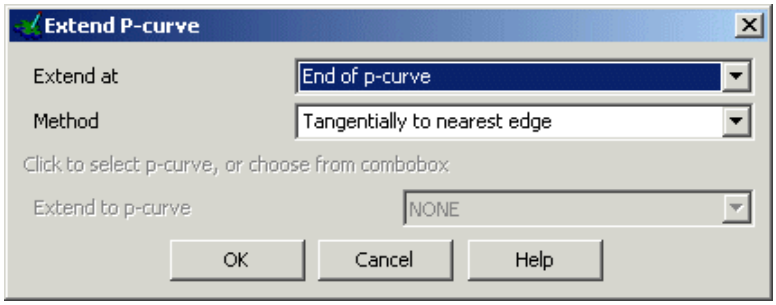
The make pcurve form appears with the options available.

- Select the option **Projected** and **click** on the **composite curve**.
- Select **OK**.
- **Deselect** the **surface** and **delete** the **composite curve**.
- Select the **lower curved surface**.



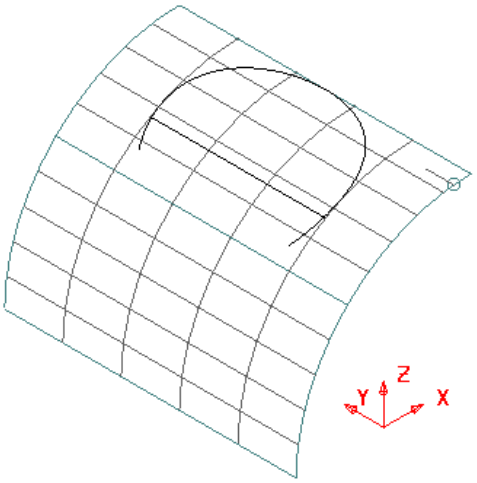
There are now two pcurves on the surface, however the linear pcurve is not long enough when creating a boundary, so it needs extending.

- **Select** the **straight pcurve** and select **Extend p-curve**.



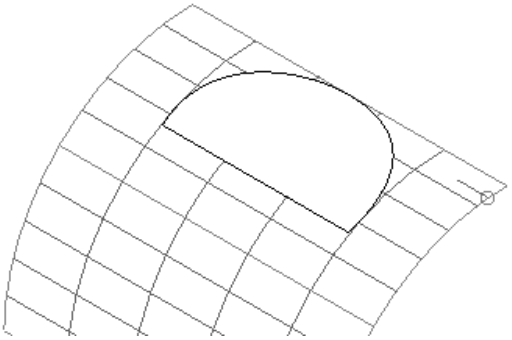
The extend pcurve form appears.

- Select extend at **both ends** and method as **tangentially to a pcurve**.
- **Select** the other **pcurve** and press **OK**.



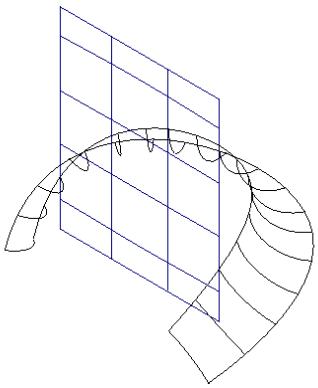
As no further trimming is envisaged on the surface, the **boundary** will be manually created using **Recreate** based on the current **pcurve** network.

- **Select Boundary Edit Mode** and select **Recreate**.
- **Click along** the **pcurves** to make the new boundary.
- Click **Save** and **Eject**.



The new boundary has been created
If the trimmed surface appears within the 'D' shape, select **Reverse the Boundary** icon to create the result shown.

- **Select Unblank** (Ctrl + L).
- **Blank** all surface apart from the front **vertical** and **fillet** surfaces.

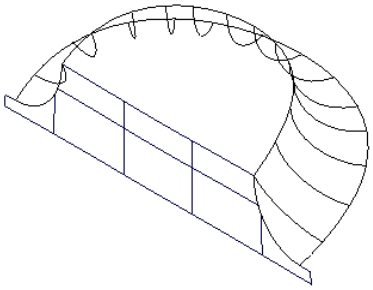


The planar surface needs trimming.

- **Select** the **vertical surface** and **Select all boundaries**.
- **Select Explode.**

More pcurves can be made by limiting the fillet to the plane.

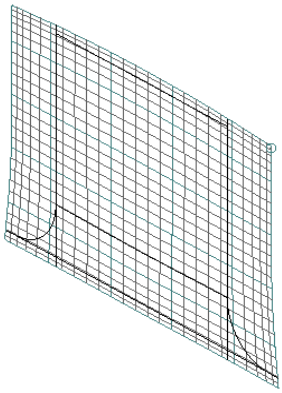
- **Open** the **Edits Toolbar** and **select** the **fillet surface.** (cutting object).
- **Select Limit selection** followed by the **vertical** surface and click **next solution** until the **fillet** is trimmed correctly.

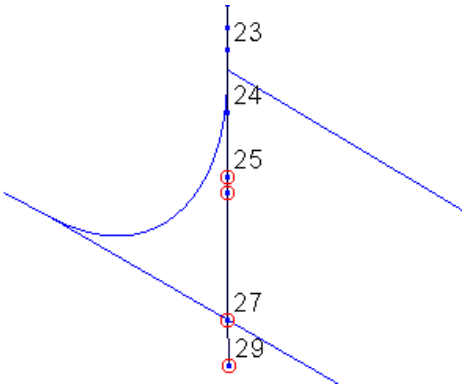


The correct trimming option for the **fillet** is achievable using **Next Solution**, but not for the **vertical** surface due to the complexity of it's **pcurve** network.

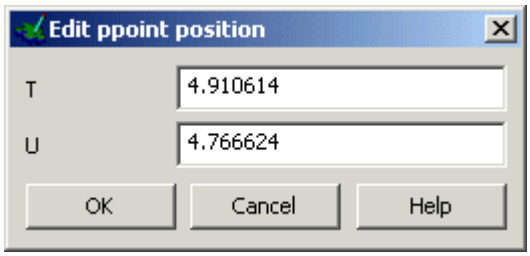
- **Dismiss** the form.

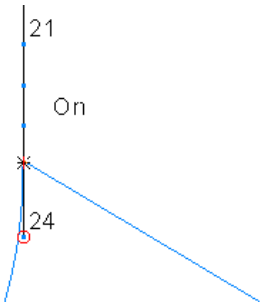
- **Select** and **Blank Except** (Ctrl + K) the **vertical** surface.
- Open the **Boundary Edits Menu**
- **Select** and **Explode** the **boundary.**
- **Select P-curve Edit Menu** to display all existing **pcurves.**



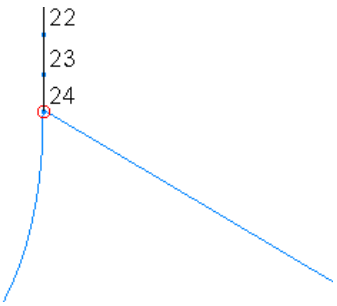


- **Zoom** into the lower left corner and select the **vertical pcurve.**
- **Delete** the **last ppoints** from the **end up** to **one before the curved join**.
- Label **ppoints** by clicking **Turn point labelling on/off** .
- **Select ppoint 24** and press **Edit parametric value at ppoint.**





- **Click** the **branch point** situated **before** the **last ppoint** (24) and note the updating of the values in the above form (**zoom** in as close as possible).
- Click **OK** and the position of the last **ppoint** (24) will update to the new parametric values.

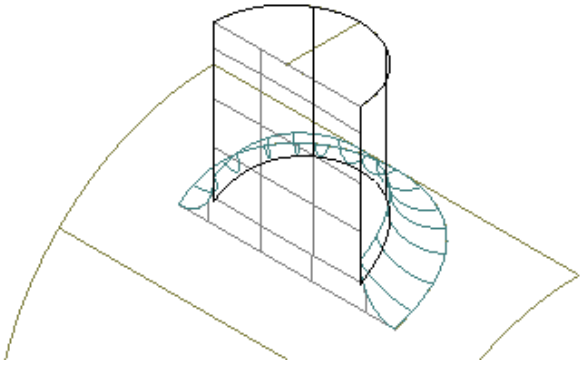


The ppoint is now matched. This procedure can be used all on all the pcurves so that you can use the Autocreate boundary feature.

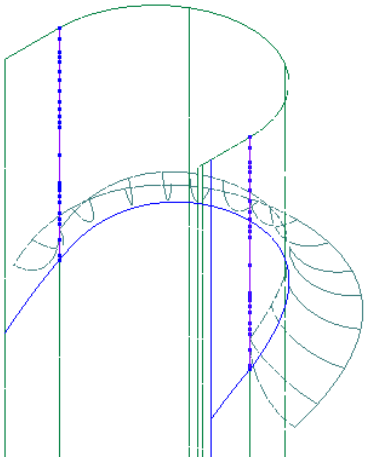
Alternatively, as long as the pcurves cross you can create a boundary using autocreate.

- **Select boundary edits** and **recreate a new boundary.**
- **Trace** a **new boundary**.
- **Select Unblank (Ctrl + L).**

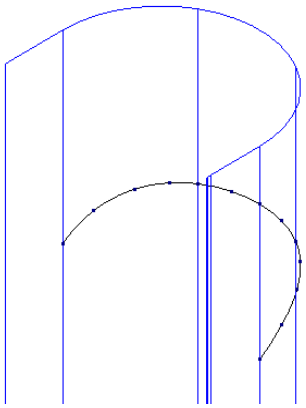
The **vertical 'D' section** surface shown below is the final surface that requires re-trimming.



- **Blank** all surfaces apart from the **fillet** and the **vertical 'D' section.**
- **Select** the **vertical 'D' section**, surface and **Delete** it's **Boundary.**
- **Select P-curve Edit Mode** and **delete** all **pcurves except** the **2** running vertically from the ends of the **fillet** surface (shown dotted below).

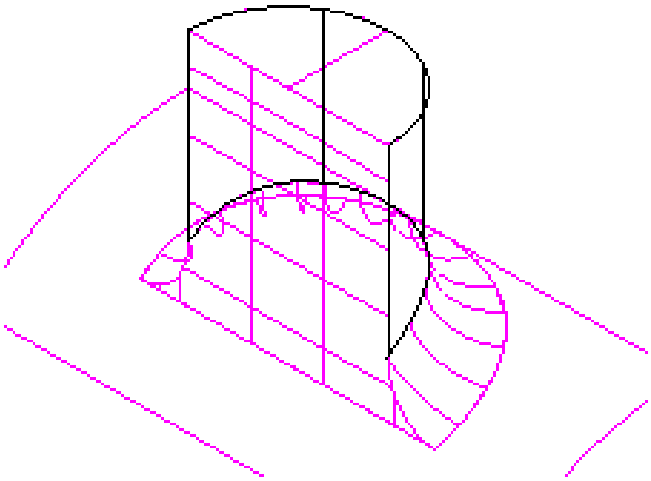


- **Create** a **composite curve** on the upper edge of the **fillet** surface.
- **Blank** the **fillet** from the view and **select** the **vertical 'D' section** surface.



The composite curve will be turned into a pcurve on the surface by projecting it.

- Select **P-curve Edit Mode** then **make pcurves from wireframe.**
- Select the option **Projected** and **click** on the **composite curve.**
- **Select OK**.
- **Select** the **vertical 'D' section surface.**
- **Select Boundary Edit Mode**.
- **Select** the icon **Recreate** and manually generate the **boundary** to create the correctly trimmed, surface shown below.



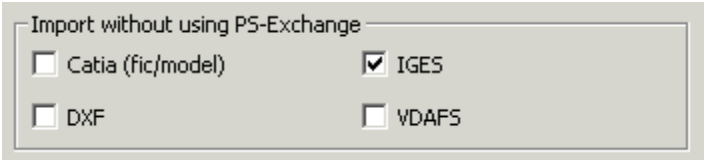
The surfaces are now trimmed to one another.

- Select **File➔ Close** and then **No**.

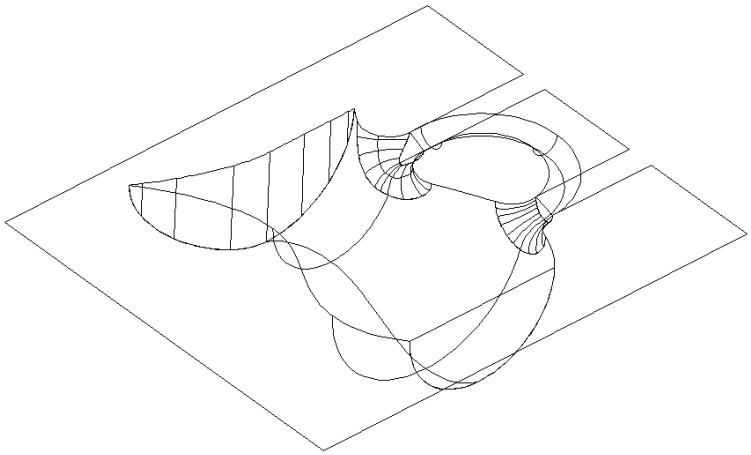
Pitcher Trimming Exercise

In this example an IGES file is imported that contains a badly trimmed split surface. With the help of the following suggestions, re-trim the surface.

- In **Tools** - **Options**, under **Data Exchange/PS-Exchange**, **tick IGES** in the **Import** section. **Select OK.**



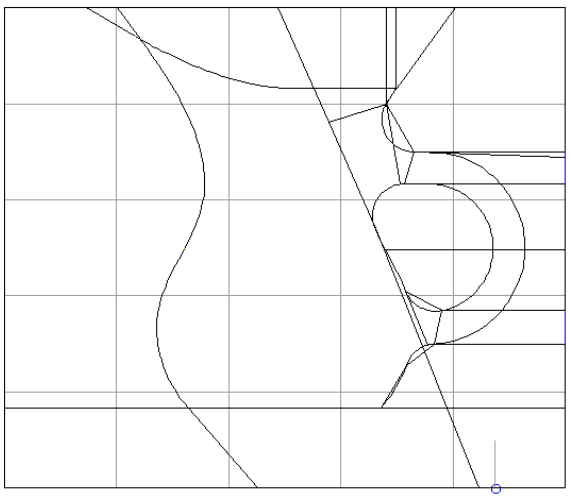
- **Import** the file **jug_split_surfaces.ige** from **PowerMILL Modelling_data/iges.**



To bring in unused pcurves PowerMILL Modelling IGES is used, not PS-Exchange. From the model, you can see that the split surface has a couple of gaps in it.

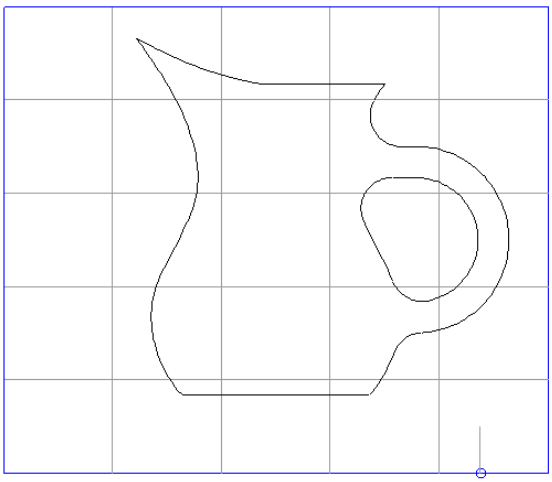
The first process is to select only the split surface and explode the bad boundary.

- **Blank** all surfaces **except** the **split surface.**
- Open the **Trim Region Editing** toolbar and select **Boundary Edits.**
- **Delete Boundary 1.**
- Select the **P-curve Edits** menu.



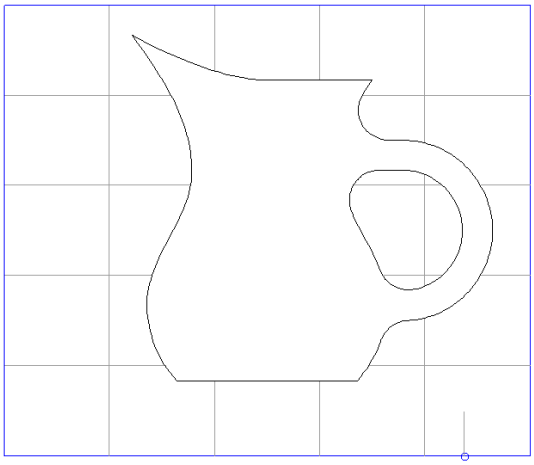
The surface contains a complex network of p-curves. The network is to be simplified by using a combination of options including delete p-curve, delete ppoint, extend p-curve, etc.
Pcurves need to be perfectly trimmed to enable automatic pcurve generation. When defining a boundary manually the pcurves do not have to be trimmed back as the required route is defined using the cursor.

- **Modify** the **P-Curves** until the surface looks like this:



The next step is to create the Boundaries. Although an automatic boundary could have been made, trace the boundary around using the re-create boundary button.

- Use the **recreate boundary** icon and trace the outer boundary.
- Press **Save**, trace the inner boundary and then **Save** and **Eject**.



The surface should now be trimmed correctly otherwise Reverse the Boundary. A quicker way of producing this result would have been to create composite curves around the top edge of the jug form. These could then be used to create projected pcurves on the split surface.

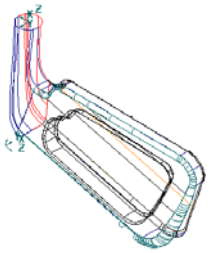
- Select **File ➔ Close** and then **No**.

11. Model Analysis

Basic Shading Options

Basic shading is displayed by clicking the various icons in the View Toolbar. It will shade all of the surfaces that are displayed in the same material. As surfaces have an inside and outside the outside is displayed in a blue colour and the inside as red.

- Open the model **golf-fin**. **Activate workplane 2**.
- Select view **ISO 4** and select **wireframe view**.

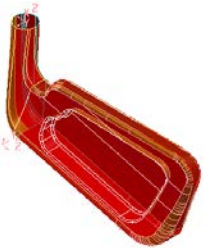


The model is displayed with the surface skin invisible, enabling visual access to the trimmed edges and surface curves.

- Select **Shaded view**.

The model is displayed with the Surface model skin shaded. The outside of a surface will be the default or a user defined colour and the inside is red. The use of shading will restrict visual access to internal detail.

- Select **Toggle Transparent wire**.

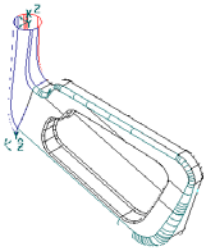


This view shows the model partially shaded transparent which provides visual access to the inner, wireframe detail.

- Select **Shaded wire view**.

This view is a shaded view, with the outer edges shown in wire mode to allow them to be picked easily for surface editing.

- Select **Hidden wire view**.



The model is displayed in wire mode, with all the internal wire removed or hidden. This is a visual option to aid the user to see the model clearly. This special view mode needs to be turned off for surface manipulation.

- From the View pull down on the main menu select **Shade > Inside Material**.

This view turns on or off the mode which displays inside-out surfaces as red. This is good to quickly visualise the model, but it does not actually reverse the surfaces.

- With the **model shaded**, select **Enhanced Shading**.

This shows the model in **Enhanced shading** mode. This type of view includes ***perspective*** and ***reflections*** on the surface giving a more true to life appearance with model feature lines, visually converging towards distant vanishing points.

- From the **pop up menu** under **enhanced shading** select **Render the View**

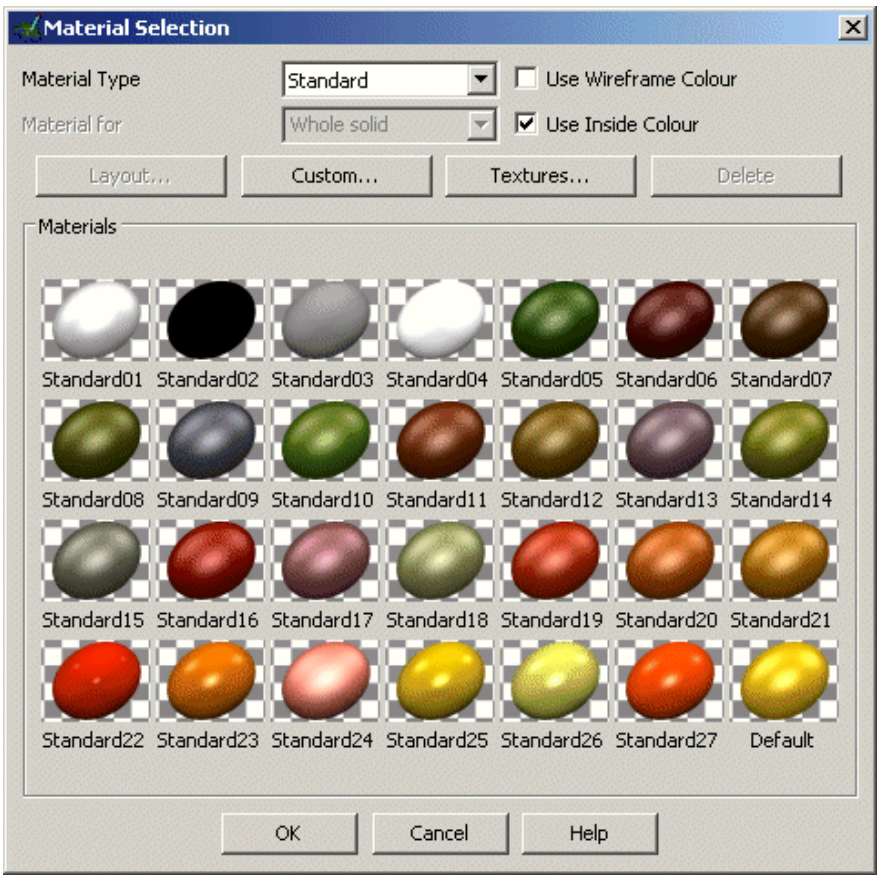
This displays a photo-realistic image of the model in a separate, newly opened graphics window, using default light settings and render options.

This function only available in full version

- Select the golf_fin :1 from the Window pull down menu.

Format – Shading Materials

Shadings materials are accessed from **Format** >**Materials** pull down on the main menu.



By default all surfaces are shaded using the same material. There is a comprehensive range of pre-set **Material** types available, such as metallic, glass, neon, etc. Individual surfaces can be modified to use a shading colour and/or material type directly from the standard range or as customised by the user.

To change the material of a selected surface(s):

1. Ensure that shaded images are displayed
2. Select a surface or group of surfaces.
3. Raise the **Materials dialogue box** and select a new material.

To change the default material:

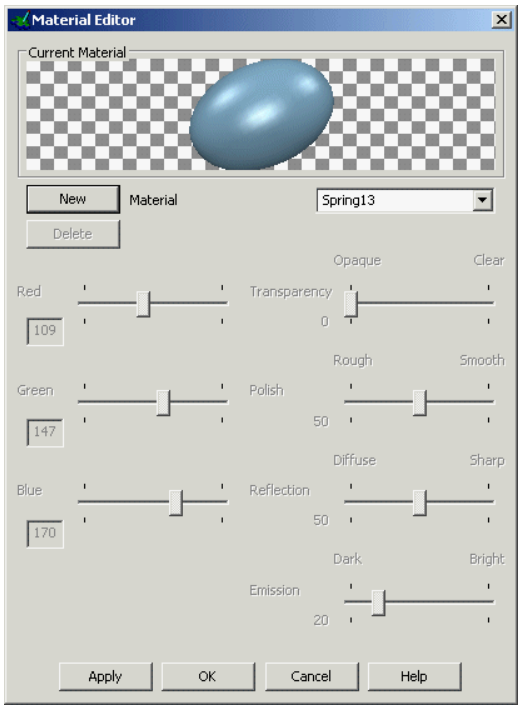
1. Ensure that no surface is selected.
2. Raise the **Materials dialogue box** and select a new material.
3. Click **OK** and the new material will be used for subsequent surface colour shading.

Customising Materials

This function only available Standalone

Users can create a custom material to their own specification.

- Select **Format -Materials** form, select **Spring** and pick **Spring13**.
- Select the option **Custom**.



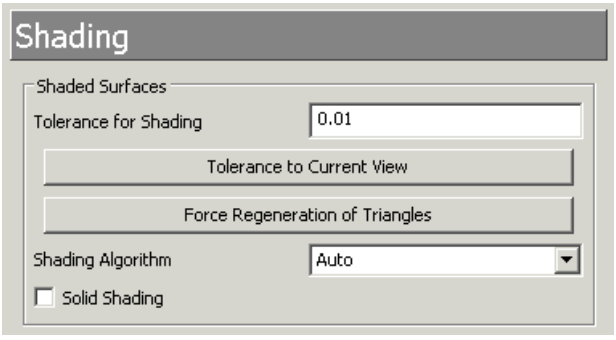
The materials Editor form appears. This form allows the appearance of the shading effect to be altered using various sliders.

- Select **New**. Leave the name as **Spring13copy**.
- Alter the material using the sliders and observe on the preview bead at the top of the form.
- Once a visually suitable material is obtained **Apply** the form.
- **Select** any surface and the material is changed to the new one.

Shading Tolerance

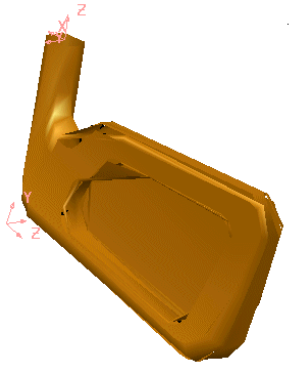
When models are shaded, the whole surface is covered in a triangular mesh, which is set at a certain tolerance i.e. the smaller the value, the finer the mesh. These values are found under the **Shading Option**, found under options in the **Tools** pull down menu.

- Select **Tools ➔ Options** and from **View**, select **Shading**.



Tolerance to current view is a quick way of entering the ideal value for your particular screen resolution and current zoom. PowerMILL Modelling will use the new tolerance the next time the shading is regenerated. If you want to see it immediately, click the button, **Force regeneration of triangles**.

- **Set** the **Shading Tolerance** to the excessive value **5**.
- Press **Force Regeneration of triangles**. Press **OK**.



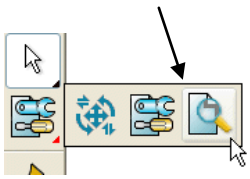
The shaded surface model appears very faceted. If it is required to check a surface model for tangencies or ripples along the surface it is essential to apply a suitable shading tolerance. This in turn depends on the physical size of the model but a popular value is 0.01 for an accurate visual representation.

- Set the **Shading Tolerance** to the more acceptable value **0.01**.

NOTE: The colours/materials used to display solids and surfaces are those selected in PowerMILL.

Model Analysis

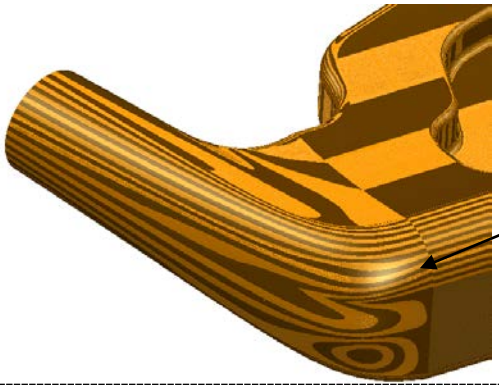
The **Model Analysis** toolbar is opened by clicking the icon located along the row 2nd from the top of the left hand toolbar.



The new left hand toolbar will contain the **Model Analysis** options. It is shown below repositioned to a horizontal alignment.

Advanced Shading Options

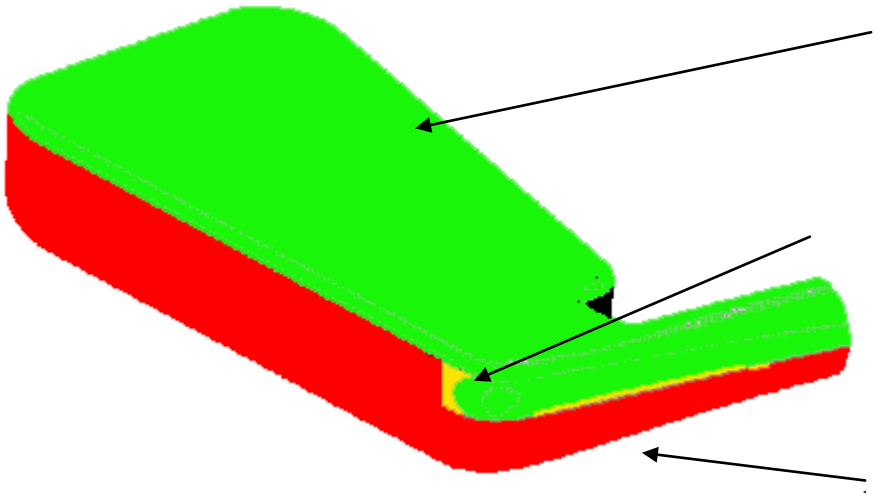
Smoothness Shading - visually exaggerates the degree of smoothness over the model surface with dual coloured stripes. A break in continuity along the stripes indicates a sharp transition form one face to another.



Note:- A Sharp cornered transition across adjacent surfaces is indicated by break in the continuity along the stripes.

- Select the above option and have a closer look at the displayed model.

Undercut Shading – Used to check for correct draft angle on a moulding component or to check for undercuts.

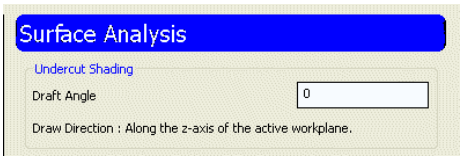


The area of the model surface shaded green does not exceed the draft angle alignment.

The small area of the model surface shaded yellow is exactly aligned to the draft angle.

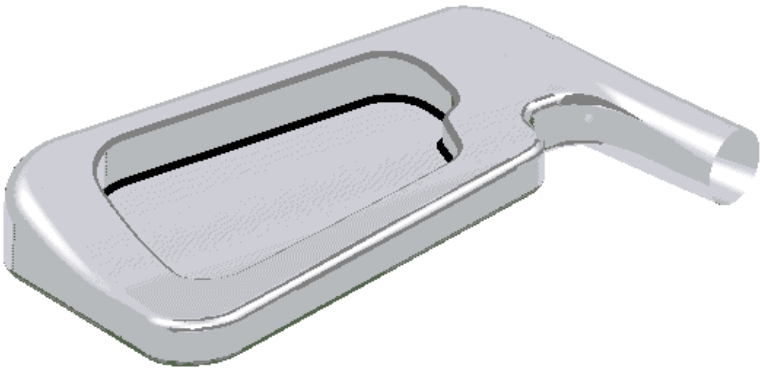
The area of the model surface shaded red represents an undercut.

By default the **Draft Angle** is set to zero. If it is required to use a different value it can be modified in **Tools - Options -Tools - Surface Analysis**.



- Select the above option and have a closer look at the displayed model.

Minimum Radius Shading – displays internal radii with a value less than the specified minimum radius in Red and external Radii in green with the remainder of the model being Grey.



This illustration represents **Minimum Radius Shading** using a minimum radius value of **2**.

By default the **Minimum Radius** value is set to **5**. If it is required to use a different value it can be modified in **Tools - Options -Tools - Surface Analysis**.

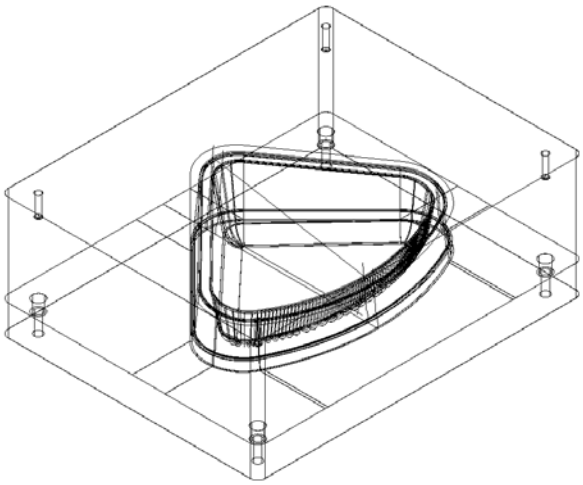
- Select the above option and have a closer look at the displayed model.

Levels

In PowerMILL Modelling objects can be assigned to different levels, which can be switched to be 'displayed' or 'hidden' to manage the selection and visualisation of entities within a model. There are 1000 Levels in PowerMILL Modelling so it is a good idea to give them useful names. Levels 998 and 999 are for internal use. It is good practise to generate a levels standard so no matter whose job the user is working on within the company they will be able to easily find the required data.

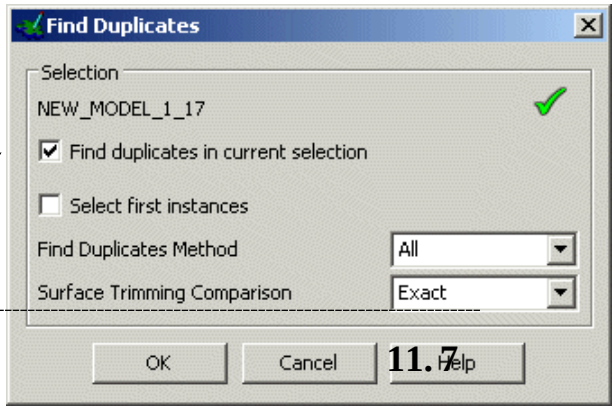
Example

- Select **Create New Model**.
- Create a **workplane** at **0**.
- **Select File ➔ Import** and then the file **Corner_Bowl.dgk** from **D:\Users\Training\PowerMILL Modelling_data\psmodels_n_dgk**.
- Select an **ISO1** view.



This model contains a mixture of wireframe and surfaces. The model may also contain duplicate entities that could either be wireframe, surfaces or a mixture of both. It is advisable to either move these items to a level or to delete them.

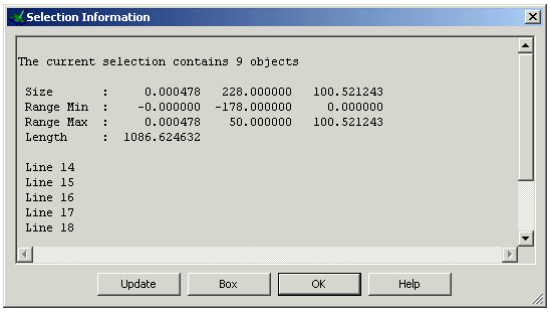
- **Select everything.**
- From **Tools ➔ Model Fixing** select **Find duplicates.**



- **Tick** the box **Find duplicates in current selection** then **press OK**.

PowerMILL Modelling examines the model fining any duplicate entities. Where it sees more than one copy of an object it selects all but one of the copies. These can be wireframe, surfaces or solids. To see what has been selected, the information icon can be used.

- **From** the **selection fly out** **pick Selection information.**



A list of the current selected items is shown.

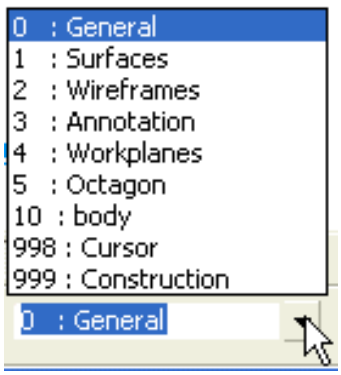
These duplicates will be moved to another level.

- Select **OK.**
- From the lower left side of the window, select the **Levels** button.
- In **Level 5**, enter the name **Duplicates** and press the big red **X** by the number **5.**
- **Select OK.**
- **Select all the wireframe** and **middle mouse click** over the new level **5.**

Clicking the middle mouse will move the selected items to that level.

- **Left mouse Click** on **level 5** button.

The left mouse will switch the level on or off. The duplicates disappear from the screen as the level is switched off.



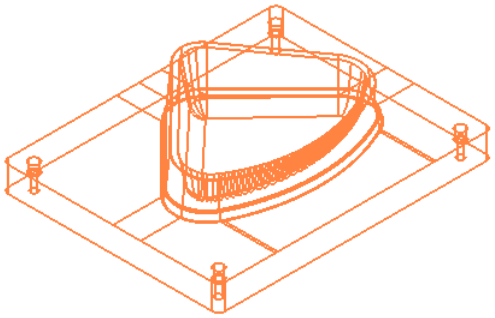
When an item is generated, the default level that it is generated on is level 0, called the general level. If, for example you wanted to always create surfaces on another level then, once the option is selected, the level is picked from the pop up menu at the end of the levels toolbar.

Choosing a level it will make it active. Be careful when doing this that nothing is selected otherwise the item will be moved to that level.

- Open the **Levels** form and create two further levels, naming **6** as **Core** and **7** as **Cavity.**
- **Select OK** on the form.

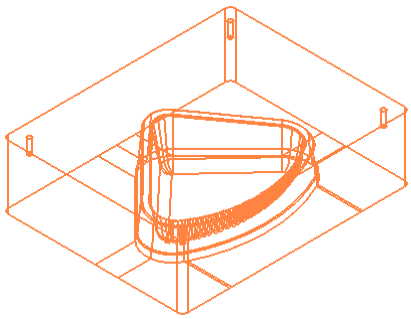
This model contains solids. These are a different type of component in PowerMILL Modelling, which can be used to make complex shapes. A solid can be selected by clicking on any part of it.

- **Select** the **bottom solid** and press **Ctrl + K (Blank Except).**



The bottom solid can be seen clearly by blanking everything apart from the selected item(s)

- **Click** the **middle mouse button** over **level 6.**
- **Select Ctrl + L (unblank).**
- **Select** the **top solid** and press **Ctrl + K (Blank Except).**



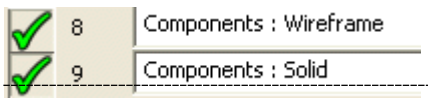
The top solid is shown.

- **Click** the **middle mouse button** over **level 7** and **Select Ctrl + L.**

The component solid and construction wireframe remain on **level 0 (General).** PowerMILL Modelling has the ability to allow **Grouping** of levels. By grouping items together the user can manage parts of the model more efficiently and effectively.

- From the lower left side of the window, select the **Levels** button.
- In **Level 8**, enter the name **Components: Wireframe** and press the big **X** by the number **8.**

- In **Level 9**, enter the name **Components: Solid** and press the big **X** by the number **9.**



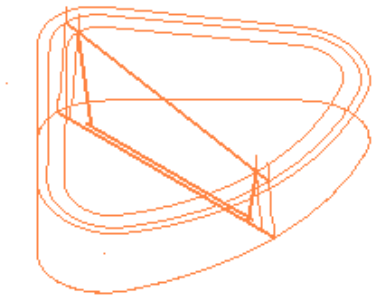
The word **Component** represents the **Group name** and the word **Wireframe** or **Solid** the **level name**.

- **Select Dismiss**

The two levels now belong to the group called **Component**. On the Levels toolbar, the following changes can be seen:

A new button appears representing the group of levels. The buttons of the two levels have changed to the same colour **(Blue).** The colour of the group matches that of the two levels. Levels can be turned on and off using the group button. If further Groups are created then a new colour will be assigned to that Group making it easily distinguishable from others.

- From the **Select** menu, select **Quick select all wireframes.**
- Press **Ctrl + K** (Blank Except).



The wireframe is selected.

Note: Whatever level is displayed in the Levels pop up menu, any items created will be assigned to that level. If that Level is currently turned OFF, a warning will be issued next time you try to create new geometry.

- **Click** the **middle mouse button** over **level 8** and **Select Ctrl + L.**
- **Select** the **component solid** and place it onto **level 9.**
- From the **Levels pop up menu** select **0 : General Level.**

In some instances it is advisable to make safe copies of surface or wireframe entities. For this exercise we will copy the core solid and paste it onto the General level 0.

- Turn on **Level 6** and select the solid.
- From the top toolbar, select **Copy** and then **Paste.**

It may appear as though nothing has actually happened, but the solid that is displayed yellow are the new copies of the original.

- **Switch off level 6.** Toggle **on** and **off Level 0** to see the new copy.
- Select **File ➔ Close** and select **No** to saving Changes.

Pump Project Example….continued

Using the pump example we can put the blanked wireframe onto a named level.

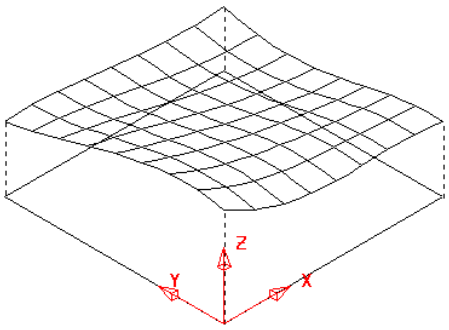
- Open the model **pump-project2.**
- Name **level 5** as **Geometry.**

- From the **Select** menu, select **Quick select all wireframes.**
- Press **Ctrl + K** (Blank Except).
- **Move** the selected wireframe to **level 5** and **switch** the **level off.**
- Select **File ➔ Save** and then **File ➔ Close**.

NOTE: When using PowerMILL Modelling it is more usual to set the level structure of the model within PowerMILL. Items on a specific level in PowerMILL will be on the same level when displayed in the Modelling environment.

Volumes

PowerMILL Modelling calculates a volume of an enclosed surface, such as a sphere, based upon the direction of the principle plane.

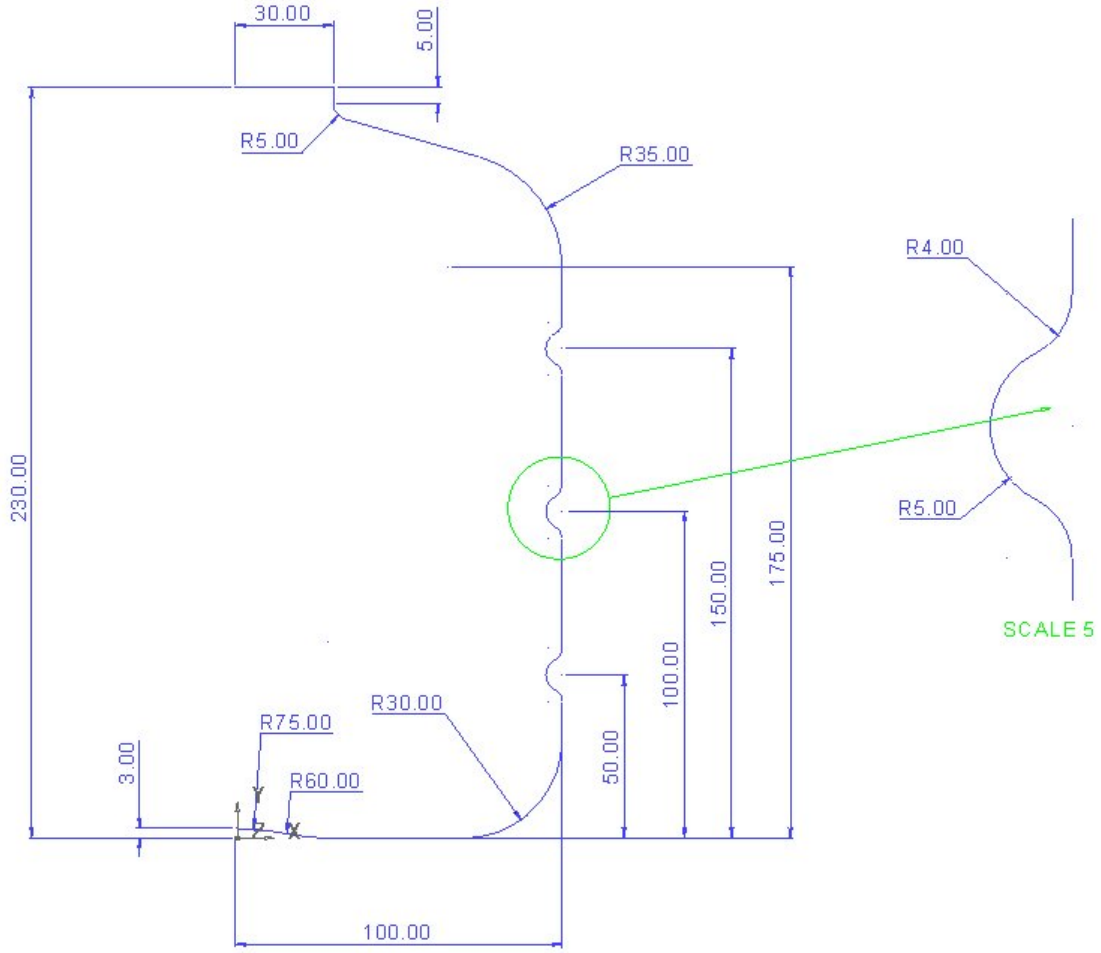


With an open surface, then PowerMILL Modelling generates a projected volume, from the active Workplane or the world origin.

The volume value given depends upon the axis in which the projection takes place, for example with the principle plane set to the XY plane; the project volume is along the Z-axis.

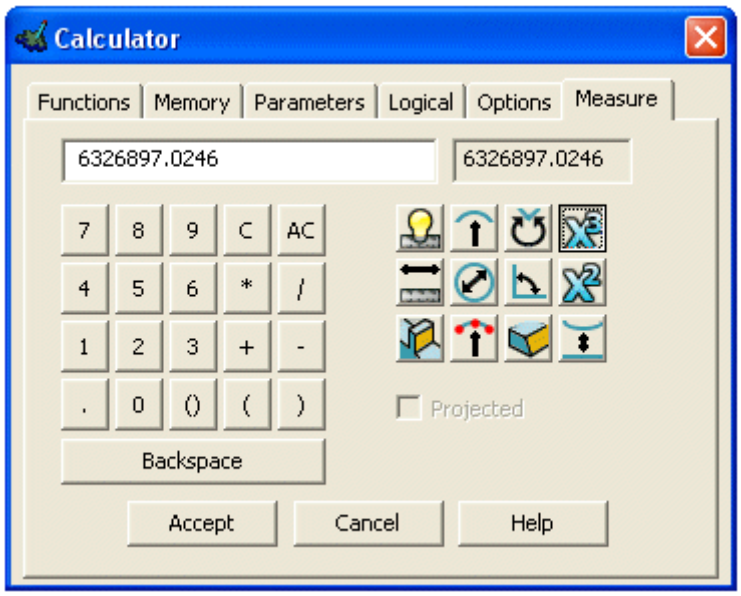
Bottle Volume Example

- Generate a **workplane** at **0.**
- Create the **following 2D geometry.**



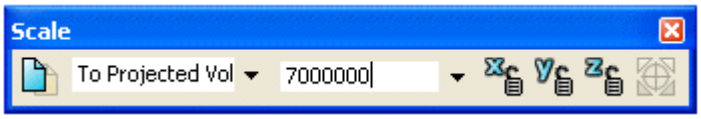
- Generate a **composite curve** of the wireframe and make a **copy.**
- **Create** a **new level** (**5**) named **Wire Copy** and place this copy onto it.
- **Switch level 5 off.**

- Create a **surface of revolution** around the **Y-axis.**
- **Shade** the **surface** and **reverse if necessary** to have a **gold outside.**
- From the bottom of the window, **select** the **calculator.**
- Pick the **volume** icon and then **pick** the **surface.**



The calculator works out the volume for you as 6,370062.9499 cubic mm. To alter the volume to 7,000,000mm cubed, we can expand the surface to this volume.

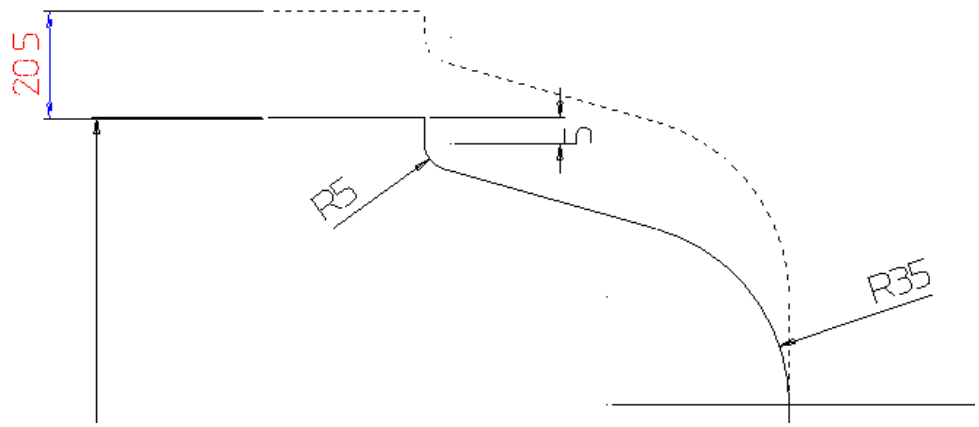
- Select the **surface** and from the **Edits toolbar** select **Scale.**
- Select the **'To Projected Volume'** option and change the volume to **7,000,000** (don't enter the commas).



A new surface is produced which is scaled in all three axes. If the X and Z movement had been locked (by clicking the padlocks) the scaling would occur only along the Y axis. Another way to change the volume would be to locally increase the length of the bottle from just beyond the top recess to the cap. By trial and error you could get close to the desired volume. The following sequence will attempt to reach the target by locally stretching by **20.5**.

- **Blank** the **surface** and switch on the level **Wire Copy** (do not select).
- Select **Stretch Object** in the **Edits toolbar.**

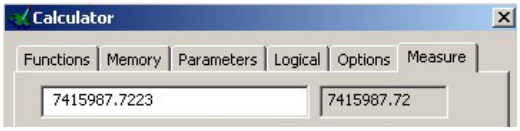
- Box over the parts of the geometry along the curve to be stretched (these will turn to yellow) and enter **0 20.5** in the command input window.



- **Generate** a new **surface of revolution**. (reverse if required).
- **Measure** the **Volume**.

To find the volume between two surfaces to find the wall thickness we can use the calculator.

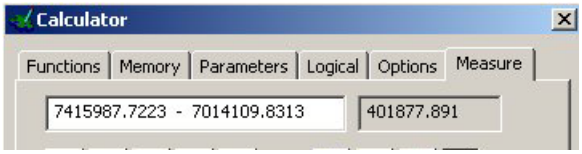
- **Offset** the new bottle (keeping the original) **outwards** by **2mm**.
- Select the **calculator** and measure the **volume** of the new larger surface.



- Enter a **minus** (-) on the calculator.

- **Measure** the volume of the original smaller surface by selecting it.

The answer, which is the volume of the thickness of the bottle, is displayed in the top right hand box of the calculator.



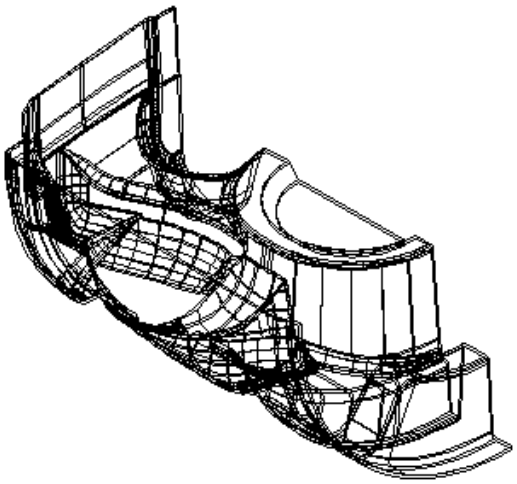
Volumes of solids can also be generated in the same way. The method also works for multiple selected surfaces.

12. Model Import/Fixing

Piston Example

The model will be split into Core and Cavity and any gaps repaired using the commands **Find Duplicates, Core / Cavity Separation, Stitch** and **Model Compare**.

- Import the ***IGES*** file **cylstart.igs** from **PowerMILL Modelling_data/Iges**.

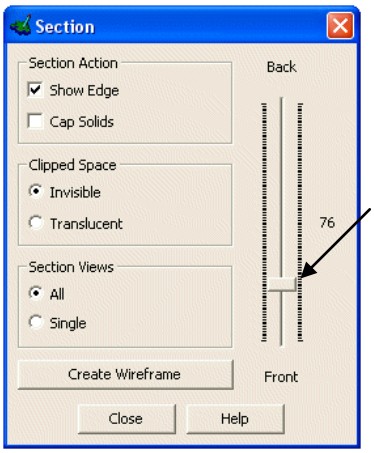


By shading the model, zooming in and out and using the dynamic sectioning to walk through the model, you can see that the IGES file contains both the Core and Cavity surfaces.

It may also contain multiple copies of the same surface. PowerMILL Modelling has a utility called **Find Duplicates**, which will select copies of the same surfaces. These can then be deleted, moved to another level or blanked.

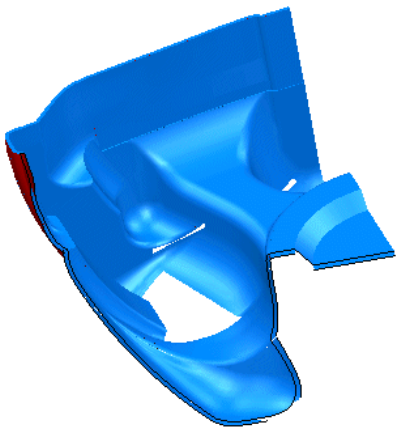
- **Shade** the **model**.
- From the pop up menu in **General Edits** select **Model Analysis Options**.

- From the **Model Analysis Toolbar select Dynamic Sectioning**.



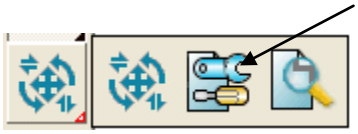
The section control appears.

The slider is used to control the sectioning, by moving it up and down the display is updated.

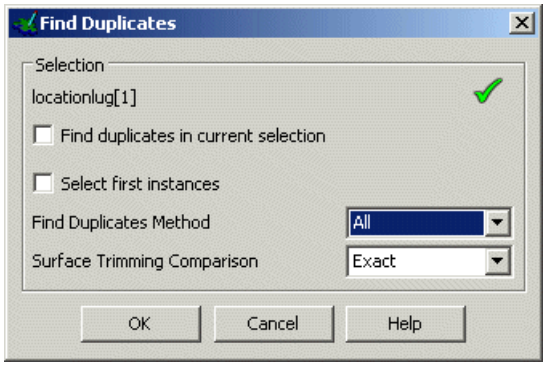


- Move the **slider** up to **50%.**

- **Select Close**.
- **Select all** of the **model**.
- From the pop up menu in **General** Edits select **Model Fixing Options**.



- From the **Model Fixing Toolbar** select **Find Duplicates**.



The ***Find Duplicates*** form appears. This gives you the option what to compare, exact, trimmed or untrimmed surfaces or whether to ignore other pcurves on the surface. Click on the Help button for a full listing.

This command selects the duplicate surfaces.

- **Tick find duplicates in current selection**.
- Select **All** and **Exact** and press **OK**.
- Select **Delete** to remove these duplicates.

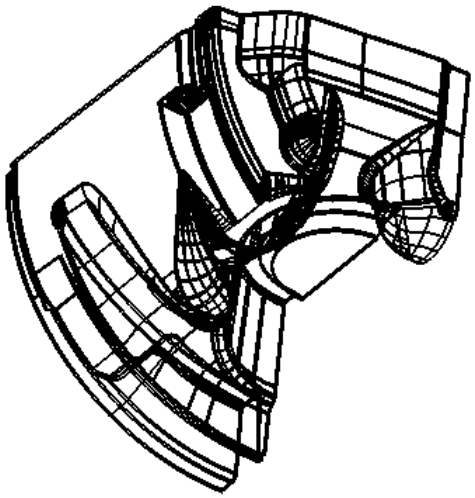
This is a moderately large model and it would take quite a while to pick out the individual surfaces that belong to the core or cavity. PowerMILL Modelling has a feature called **Core / Cavity Separation**, which can separate the core surfaces (visible) from the cavity (hidden), based on the current Z-axis.

- Name **level 5** as **Cavity** and **level 6** as **Core**.
- **Select all** of the **surfaces**.
- From the **main** toolbar select the **Wizards** Options.

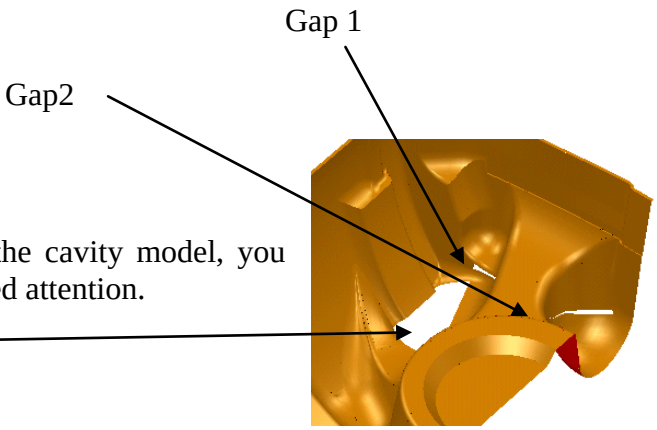
- From the **Wizards** options select **Core/Cavity Separation: Split Visible**.

The surfaces that are visible if looking down the **Z Axis** direction are selected while those shielded from being visible are not selected. Note: if there are gaps in the visible upper surfaces then any **surfaces** partly visible as a result will be regarded as being visible!

The lower **surfaces** will be assigned to **level 5** (cavity) and the Upper **surfaces** will be assigned to the **level 6** (core).

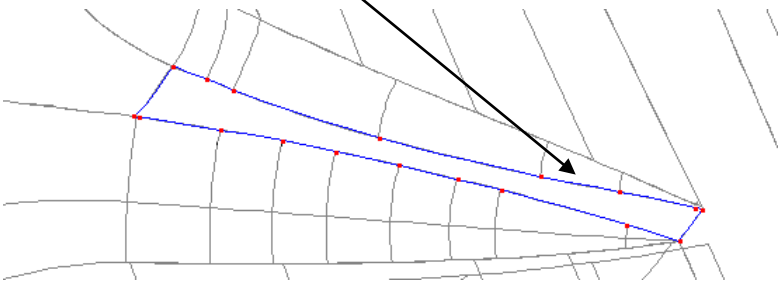


- Press the **middle mouse button** over **level 5 (cavity)**.
- **Select** the remaining **surfaces** and put on the **level 6 (core)**.
- **Switch on level 5**.
- Save the model as **D:\Users\Coursework\piston-project3**.



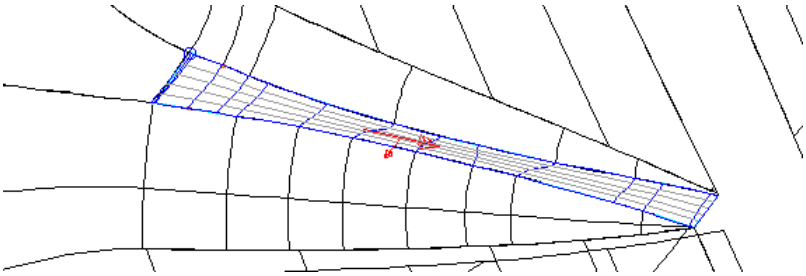
By shading and dynamically rotating the cavity model, you will notice 3 areas with holes in that need attention.

- **Zoom** into the area by **gap 1**.
- **Move** the **surface** behind the gap onto **level 5**.
- **Create** a **composite curve** using the edges of the gap.



A new surface from a network of curves can be generated using this traced composite curve.

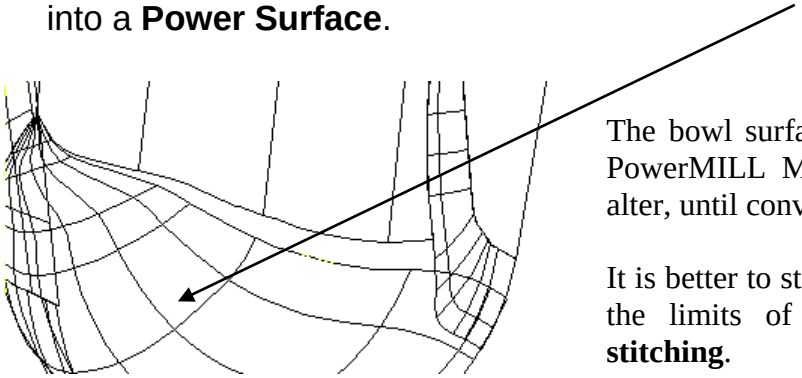
- Using the **Surface Wizard** create a **Fill-in Surface**.



The Network of curves option gives the best result.

- Move the **new surface** onto **level 6 (*core*)**.

- **Zoom** into the area around **gap 2**. Select the **bowl surface** and **convert** into a **Power Surface**.

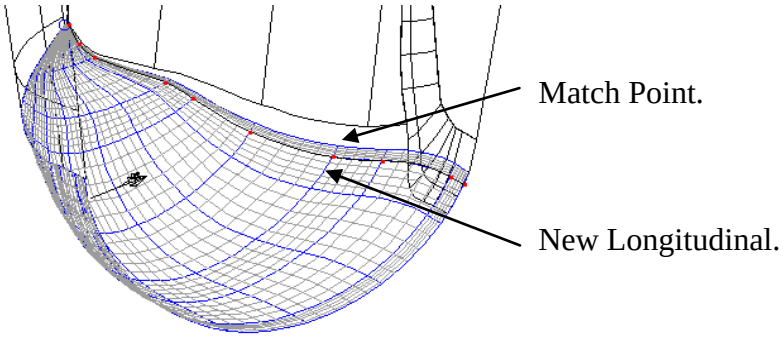


The bowl surface is a NURB surface, which PowerMILL Modelling can read but cannot alter, until converted.

It is better to stretch the round surface to meet the limits of the edge surface by using **stitching**.

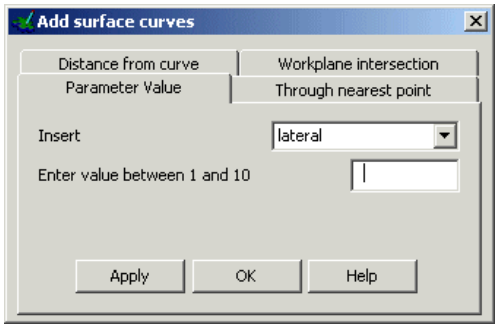
Stitching will move selected points to meet the edges of other surfaces or composite curves. An easy way of adding in another lateral dynamically is selecting a point near and using CTRL and mouse button 1 to drag in another lateral. This additional lateral is needed to hold the shape, as stitching will physically move the end points.

- **Select** the **surface** to bring up the **Surface Edits** toolbar.
- Select a **lateral/longitudinal point** and **drag** a new longitudinal near to the end one using **Ctrl** and **left mouse button** as seen below.



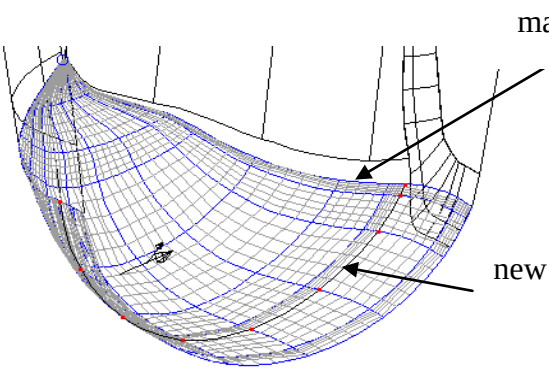
Another lateral is needed to line up with the match point so that when we stitch across it will help align the surface when it is stitching.

- Select **Add Curve**.



The **Through nearest point** option allows you to pick a point on the model. Once picked the XYZ co-ordinates are loaded into the form. If you know the exact position, that could be entered directly or the position icon used.

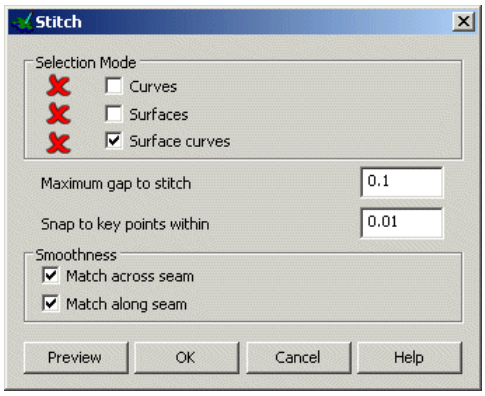
- Select **Insert – Lateral**, **Through nearest point** tab and click on the **Match point** indicated earlier.
- **Apply** the form and then **OK**.



The new lateral is generated.

The Stitch command uses the selected curve to stitch and a surface edge to stitch onto and an idea of the gap distance to stitch across. It is generally uses for small gaps.

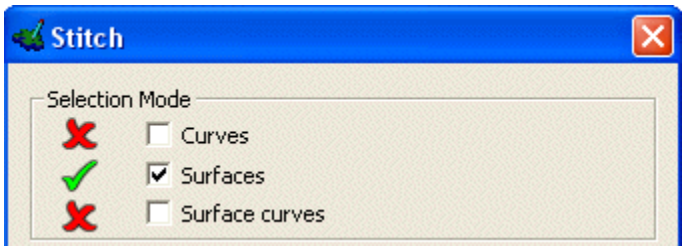
- Select the **match edge (end longitudinal)** of the round surface and then **Stitch**.



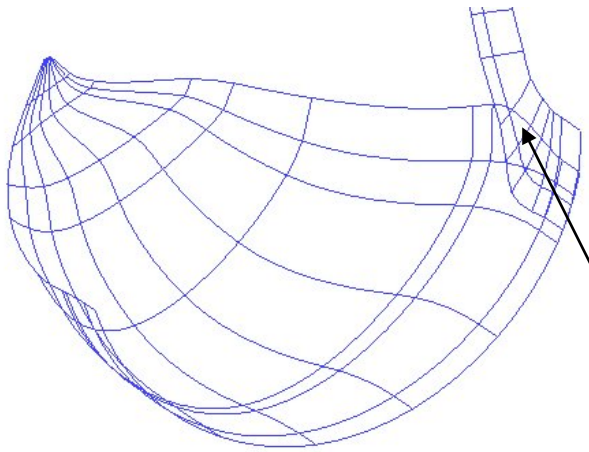
The stitching form appears. This form allows you to select the surface and edges to stitch and set the maximum gap to look for the other edge to stitch onto.

- Enter **2** in **Max gap to stitch**.
- Pick the **edge surface** on the edge curve to stitch onto.

The Green Tick nest to Surfaces indicates that the target surface has been picked



- Press **Preview** and **OK** to perform the stitching.

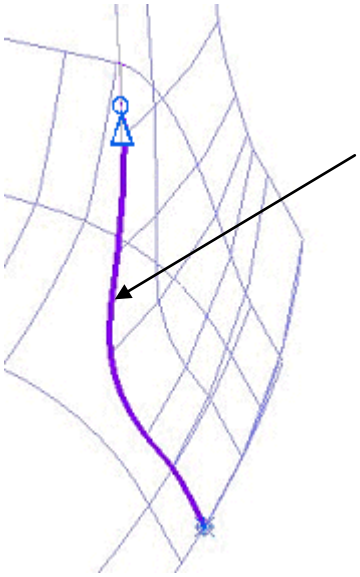


The surface has been stitched.

The round surface needs limiting back to the flange surface to finish off this area.

Flange surface.

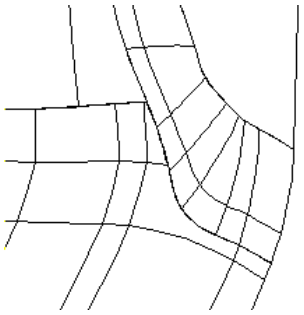
- Select the **two surfaces shown** and **Blank Except** (**Ctrl +K**).
- Create a **composite curve** from the edge curve of the flange surface as shown below.



Use Define Start and End points on the Composite Curve dialogue to create the curve shown.

- Select the bowl surface and enter into **Trim Region Editing**.
- Select the **Pcurves menu** and **make pcurves from projecting wireframe**.
- In the form select the option **Projected**.

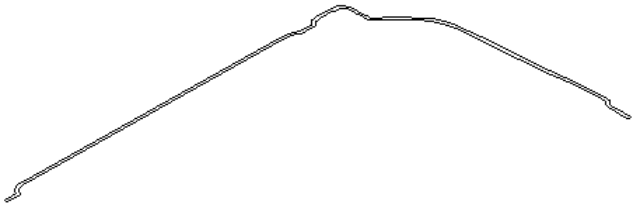
- Select the **composite curve** and **select OK**.
- Select the **Boundary menu** and **Recreate**.
- Create a **Boundary** along the fillet edge to leave the result shown.



The bowl surface is now trimmed neatly to the flange.

Before Gap 3 is filled, a split surface needs to be generated. This is achieved by selecting the top trimmed surface and then altering the trimming to produce a different surface.

- **Unblank** all of the surfaces.
- Select the **top thin trimmed surface** and **blank** all of the other surfaces (**Ctrl K**).

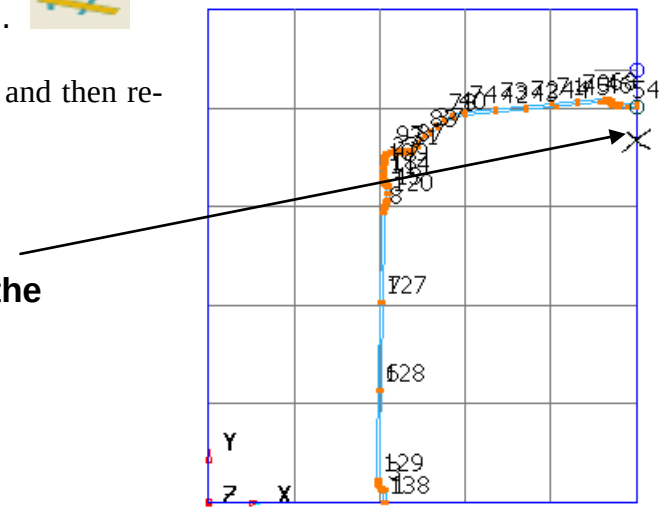


- Select **Convert Surface** and enter **Trim Region Editing**.
- **Delete** the **boundary** on the surface by selecting **Explode**.

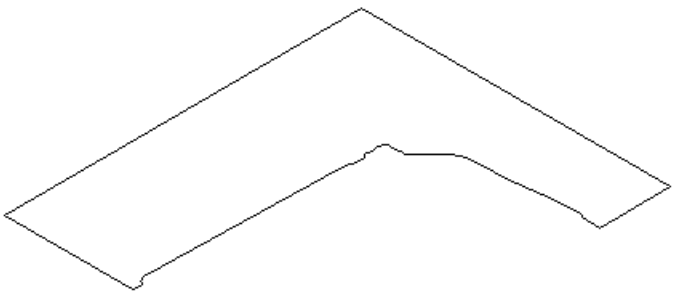
- Select the **Pcurve edits** menu.

This pcurve needs to be broken in half and then re-trimmed to generate a split surface.

- Select a **view down Z**
- **Zoom** into the **area** shown.
- **Select** the **lowest ppoint on the surface edge indicated**.



- **Select Break p-curve** to split the pcurve at the **selected ppoint**..
- Select the **outer pcurve** and select **delete**.
- Create a **new boundary** using the remaining pcurve and rear edge of the surface to give the result shown below.

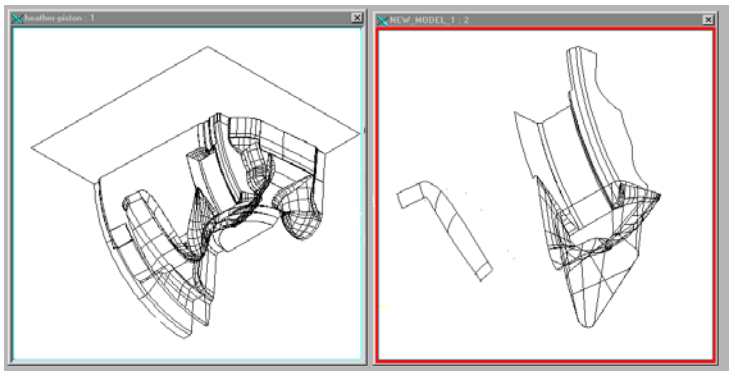


The split top surface has been generated.

- **Unblank** all of the surfaces and **save** the **model** as **D:\Users\training\Coursework\temp-piston.**

Gap 3 is a large hole in the model, due to missing data, to be supplied later in another IGES file. By loading it into a New Model it can be checked before putting the data into our piston model.

- Create a **new model** and **Import** the file **cyl1_1_2.igs**.
- Rearrange the models using **Window ➔ Tile**.

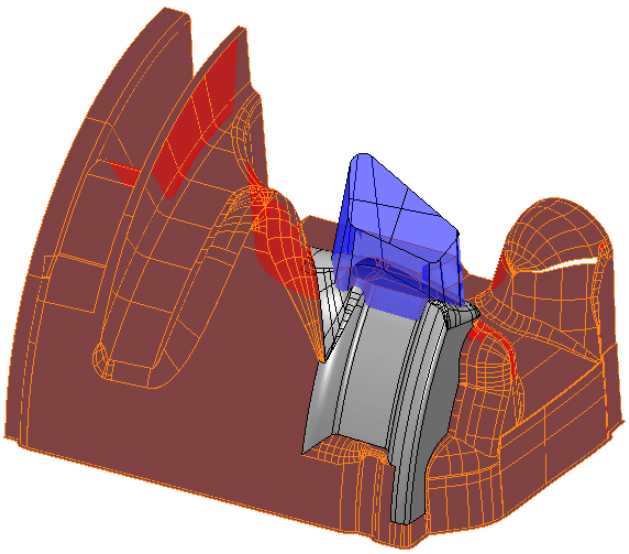


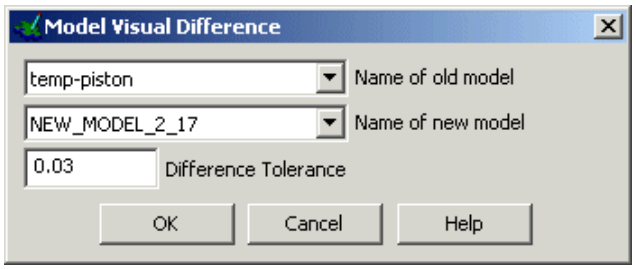
Often it can be difficult to locate engineering changes when receiving a new version of a model from a customer. Fortunately PowerMILL Modelling has an option which allows the user to make a quick visual comparison of two models to locate any changes.

- Open the **Model Analysis toolbar**.
- Select **Model Visual Difference**.

This function only available Standalone

- In the form check that the **New Model** and **Old Model names** are correct and press **OK**.





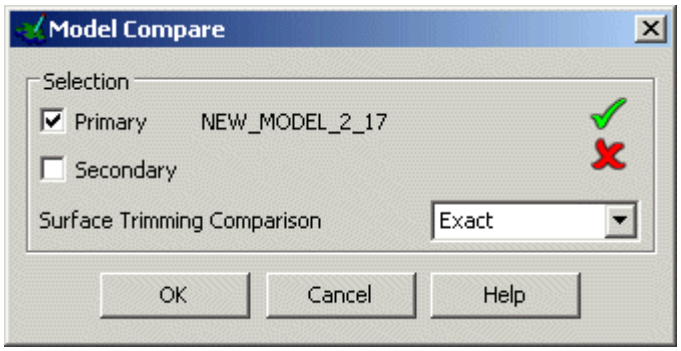
A new window will appear in which differences between the two models are highlighted. Items that are only in the old model are shaded transparent red.

Items that are only in the new model are shaded transparent blue. Items that are common to both models are shaded solid silver. This allows the user to quickly identify where changes have been made.

- **Close the window**

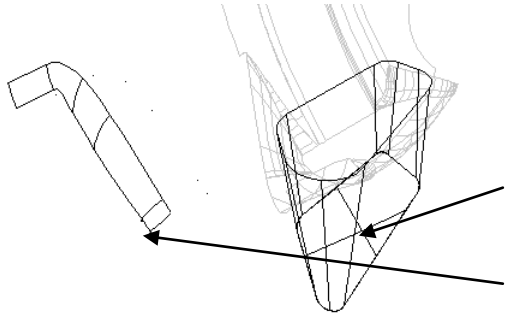
The Model Visual Difference option is a useful way of making a quick comparison. However it may be possible for the user to miss small differences on large complex models. A second option, Model Compare allows the user to select the parts of the new model that are different to the old model.

- From the **Model Analysis toolbar** select **Model Compare**.
-



The model compare form appears. This form allows you to choose which model is the primary (old) model and which model is the secondary (new) model. The differences in the model are selected in the primary model.

- Click on **Primary** and then click in the **New Model** window.
- Click on **Secondary** and then click in the **temp-piston** window.
- **Select OK**.



There is some wireframe data and an extruded surface that have been highlighted in the Primary New Model window.

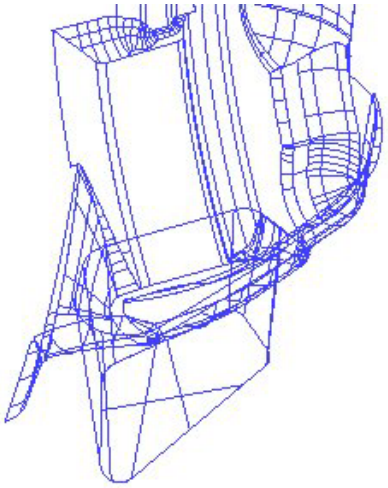
Extruded surfaces.

Wireframe.

- **Blank Except** the selected items (**Ctrl K**).
- Select the **wireframe** only and **Delete** it.
- **Select** the extruded **surfaces** and select **Copy Selection**.
- **Select** the **model temp-piston** and **select Paste from clipboard**.

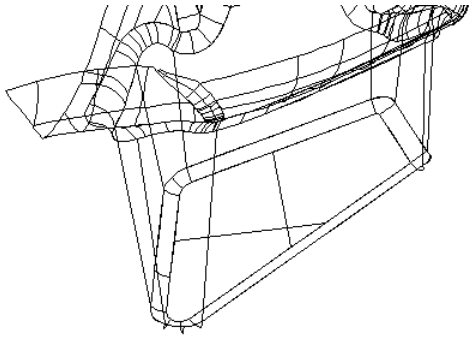
The extrusion surfaces should now be seen in the original model.

- **Close the New Model** to leave just the original model open.
- Put the new surfaces on the **level 6 (*core*).**



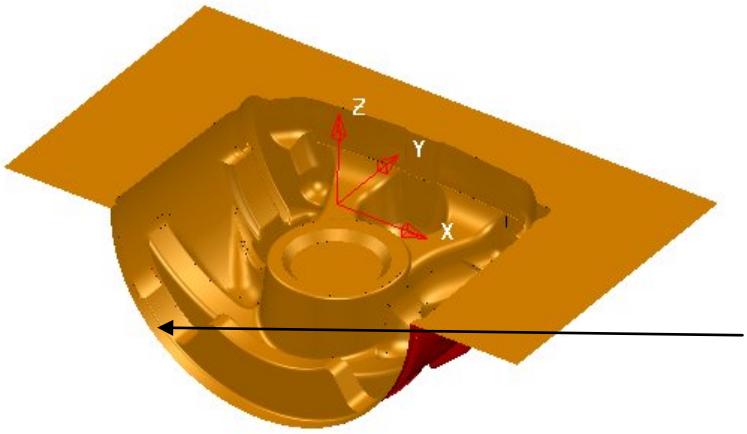
The deep pocket will be filleted to the main surfaces and the bottom edge will be filleted.

- **Select** the newly copied surfaces and those that intersect them.
- **Select Blank Except**.
- **Convert** the **tapered surface**.
- Select all of the surfaces and **Reverse** them so that they are **Gold on the outside**.
- **Generate** a **3mm concave fillet** between the **sides** and the tapered box.
- **Select** the **taper surface** and the **flat bottom**.
- Create a **2mm convex fillet** between these surfaces.
- Select all of the surfaces and **Reverse** so that **Gold is inside**.
- **Move** the **fillet surfaces** onto **level 5: cavity**.



Now that the cavity half is complete we are going to create a workplane to mirror the surfaces.

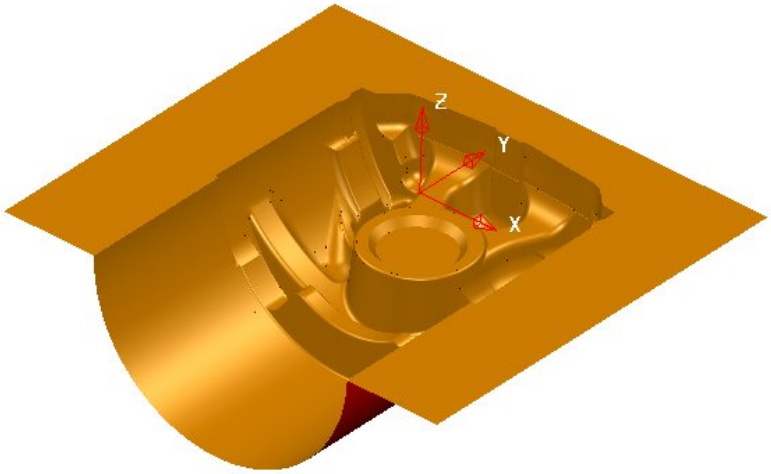
- **Select Unblank** and **create** a **workplane** at **0**.
- **Select all** of the **surfaces**.
- From the **General Edits toolbar** select **Mirror**.
- From the **Mirror toolbar** select **mirror in YZ**.
- **Dismiss the form**.



Both sides of the model are shown. However, to complete the model, an extruded surface needs to be generated to provide a split/run off surface.

The extrusion will be generated from this edge

- Create a **composite curve** along the left edge of the model.
- Create a **surface of extrusion** using the composite curve **90mm** along the **Y-axis** to give the final result shown below.



The model is complete.

- **Save** the Model.

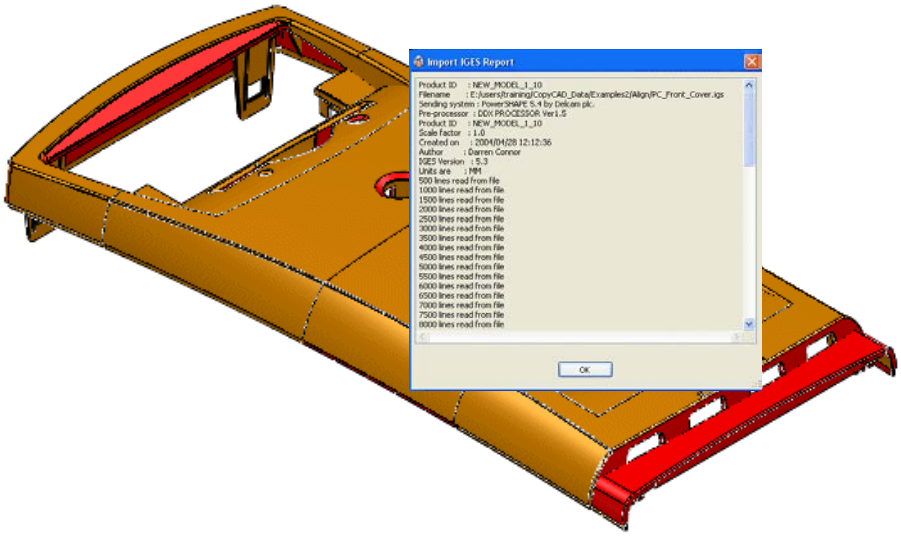
Further Model fixing

imported iges file of a PC Front Cover surface model

On import an **iges** format model will produce **Nurbs Surfaces**, which as explained in the earlier chapter have very restricted editing capability. As will be illustrated during this example when a **Nurbs** is converted it can end up producing an excessive number of **laterals/longitudinals** on the resultant **Power Surface**. It will also be observed that several of the **surfaces** are in an orientation with the inner (red) side on the external faces of the

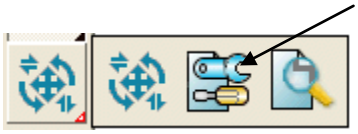
model. Apart from the visual presentation this could potentially cause problems if the model is to have additional surfacing work carried out on it (eg. Filleting).

- **Import** the model:- **….\PowerMILL Modelling_Data\iges\PC_Front_Cover.igs**

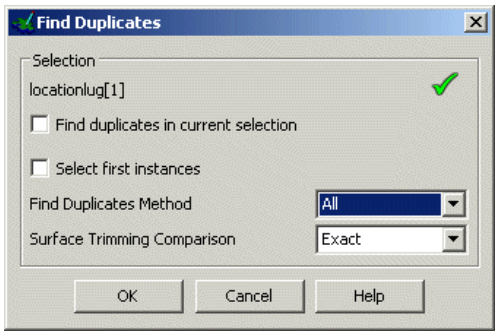


Note:- A form appears displaying the progress as an ***Import IGES report***.

- **Select all** of the **model**.
- From the pop up menu in **General** Edits select **Model Fixing Options**.



- From the **Model Fixing Toolbar** select **Find Duplicates**.



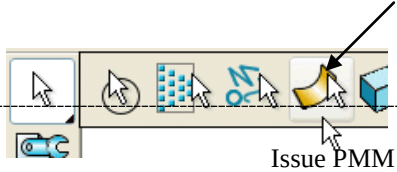
The Find Duplicates form appears. This gives you the option what to compare, exact, trimmed or untrimmed surfaces or whether to ignore other pcurves on the surface. Click on the Help button for a full listing.

This command selects the duplicate surfaces.

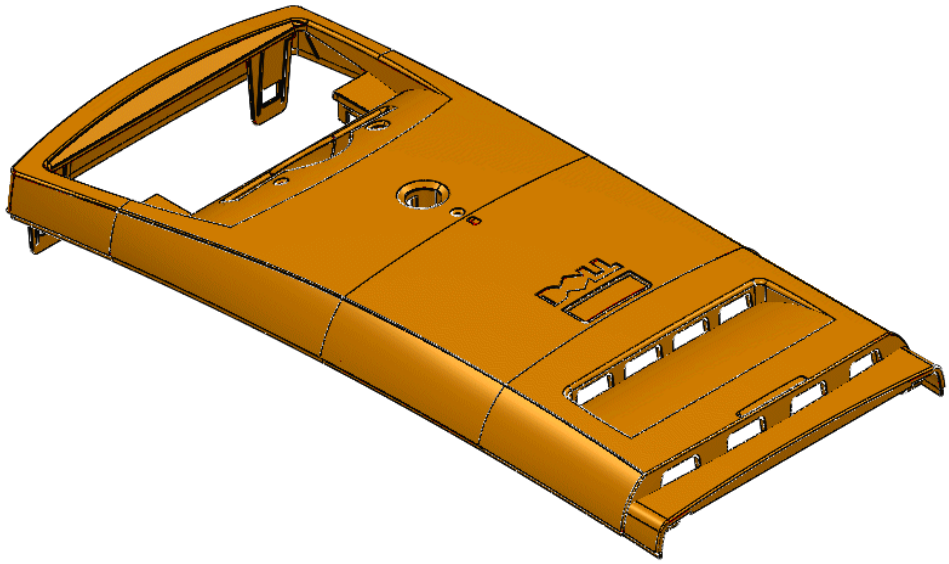
- **Tick find duplicates in current selection**.
- Select **All** and **Exact** and press **OK**.

In this case no duplicate data is found, but it is still essential to perform the test.

- From the vertical toolbar click the **Quick Select all Surfaces** option.



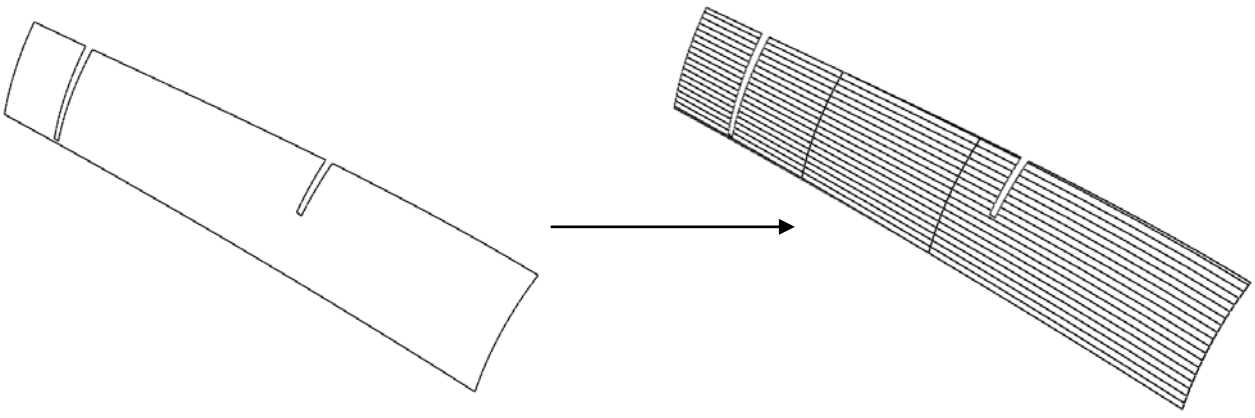
- In the **Model Fixing** options click on **Orient surface normals** to arrange for the outer faces of the surfaces in the selection to be on the outside of the component.



Note:- In some instances it may not be obvious which way a **surface** should be orientated (If the model is missing data causing a **surface** to be isolated, or the outer face of a **surface** exists on both the inside and outside of the model). If any such **surfaces** remain in the wrong orientation then they can be selected and **reversed** individually via the local menu.

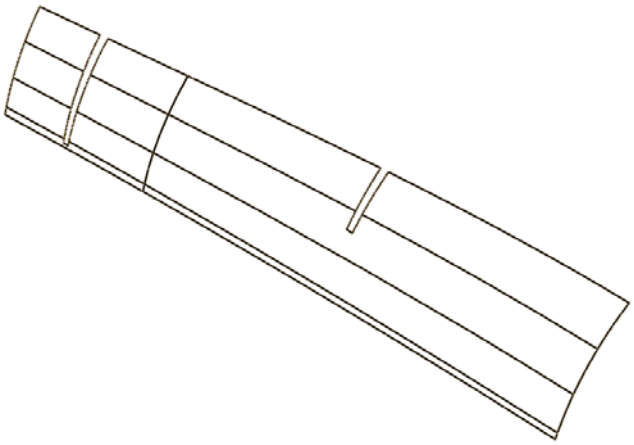
- With all the **surfaces** still selected, right click over them and from the local menu, select **Convert Surface** to change all of the selected **Nurbs** to **Power Surfaces**.

Shown below is one of the **Surfaces** before and after conversion.

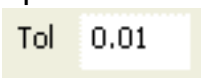


Depending on the type of file originally translated into iges format, the resulting **Power Surfaces** are often created with an excessive number of **surface curves** (as illustrated above right). If a large number of **surfaces** are involved it can result in reduced processing times and excessive memory consumption. As a result it is good practice to apply the **Approximate Surface** option to reduce the amount of curves while keeping the surface definition within a specified **tolerance** value.

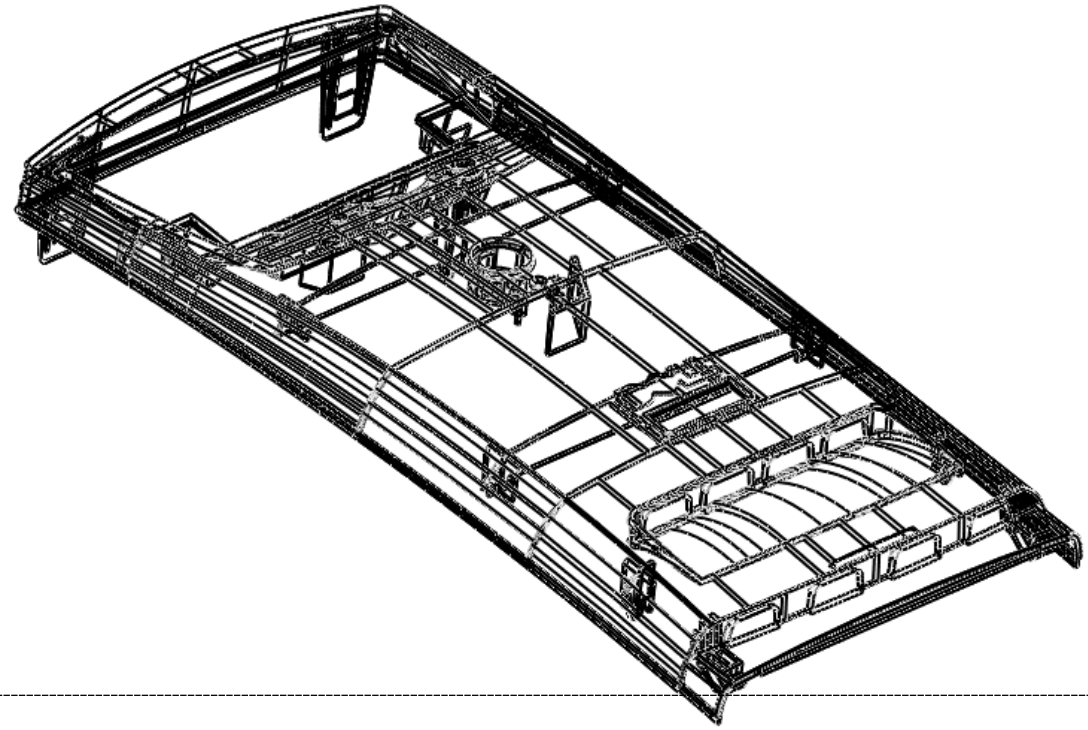
- With all **Power Surfaces** selected click the **Approximate surfaces** option located in the **Model Fixing** toolbar.



All **surface curves** are deleted that are not required to keep the model form within the ***general tolerance*** value (default **0.01**). This value can be modified on the **instrument toolbar** located below the graphics area.



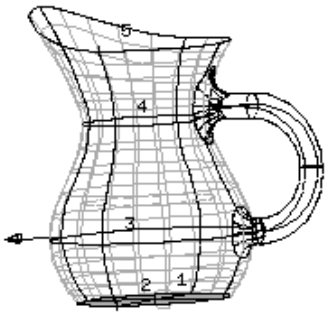
The model is now ready for further operations such as constructing the components required for a suitable mould tool design.

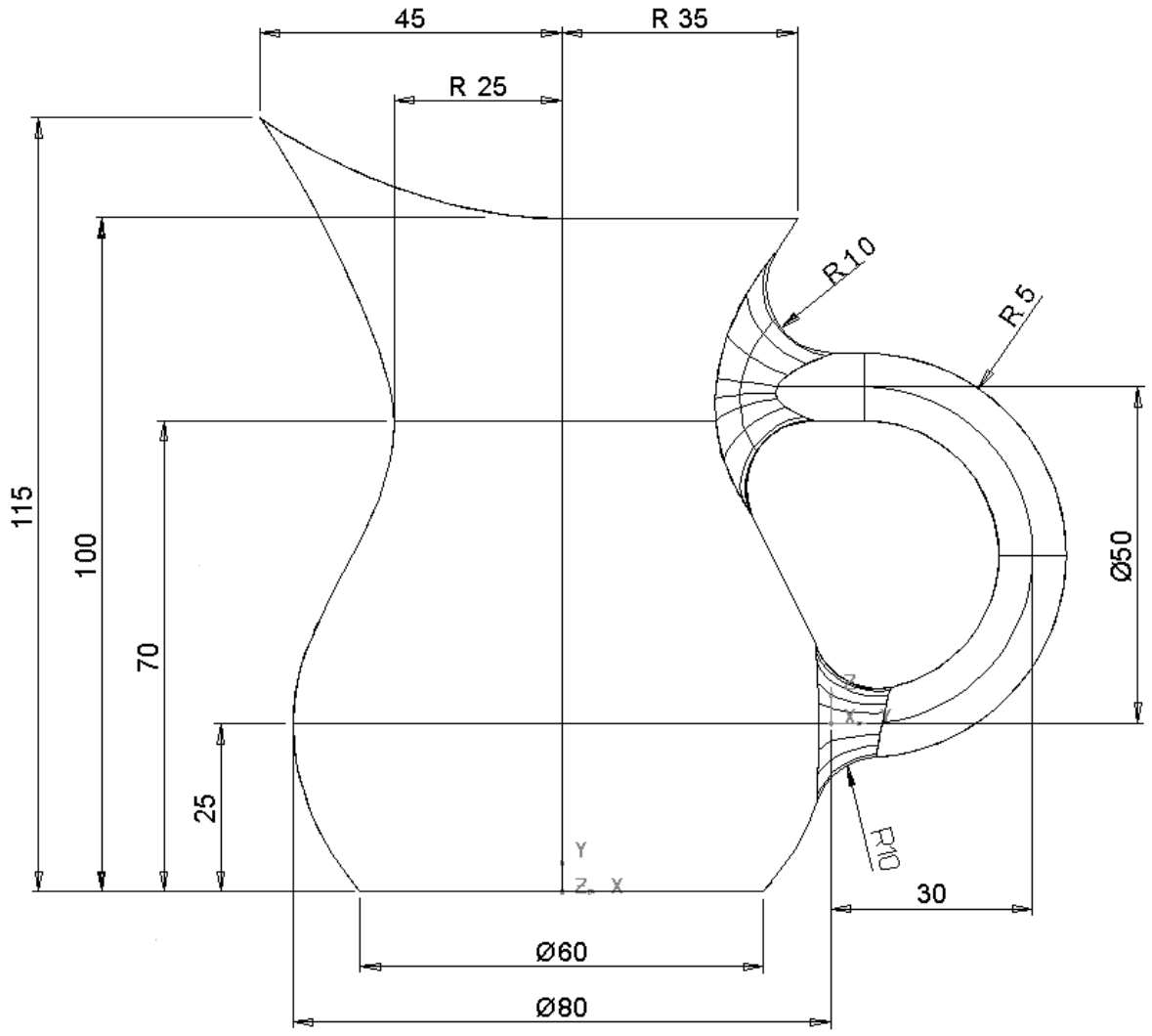


13. Exercises

Jug

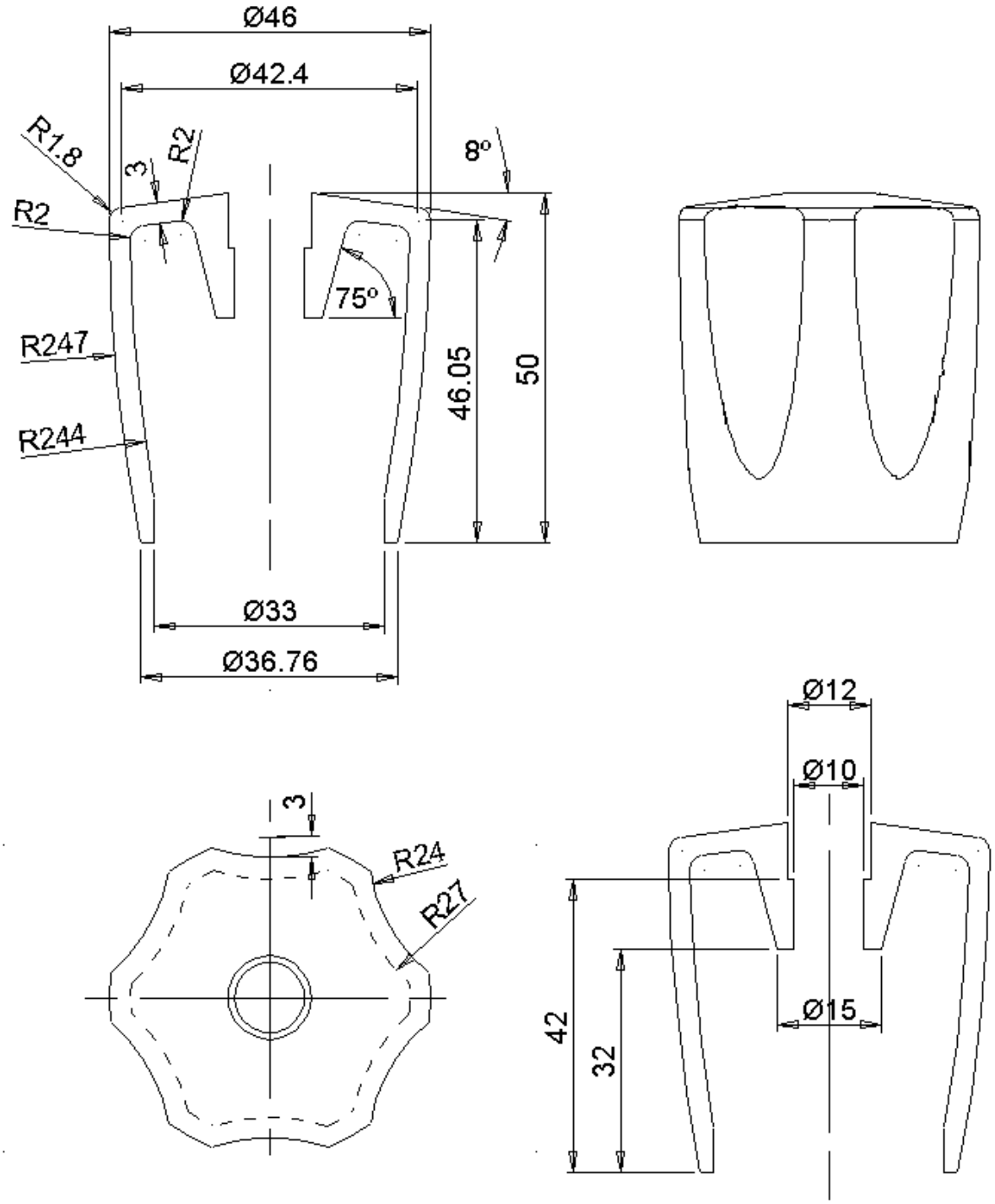
Model the jug.





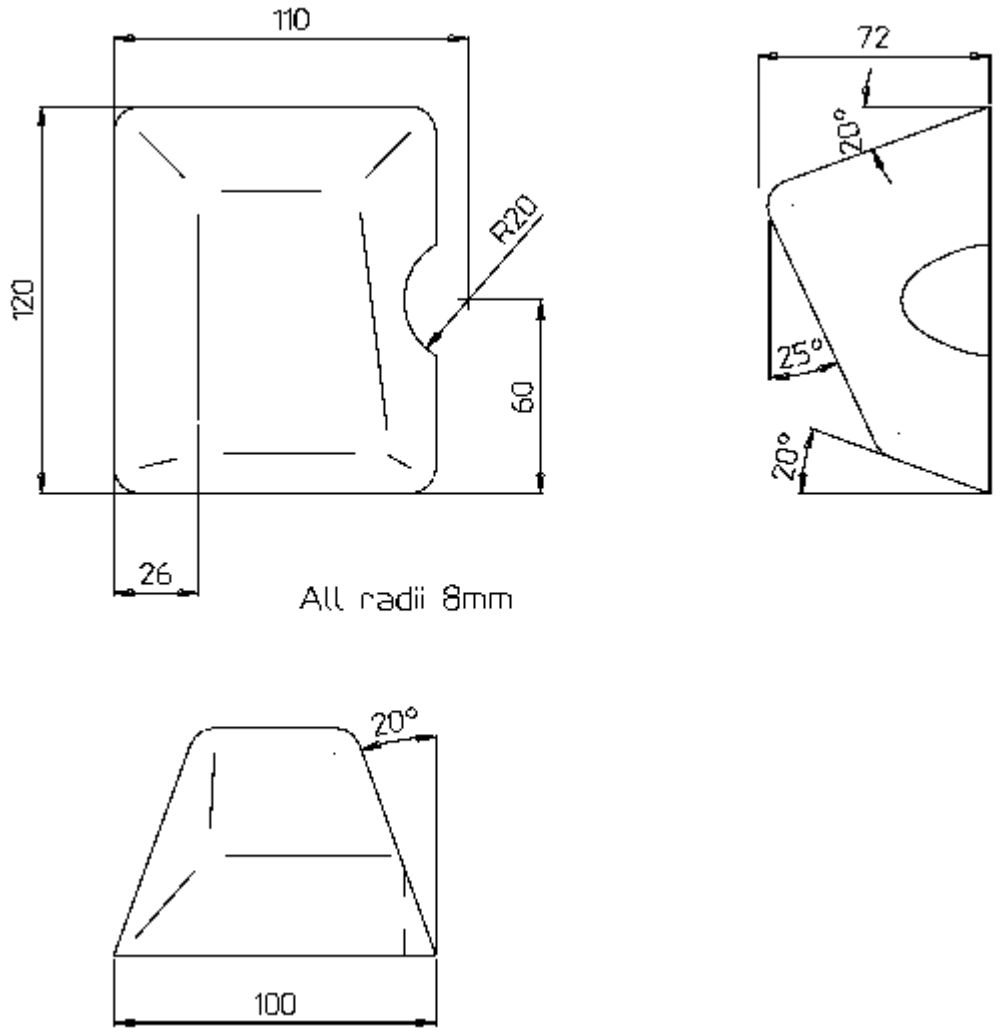
Radiator Knob

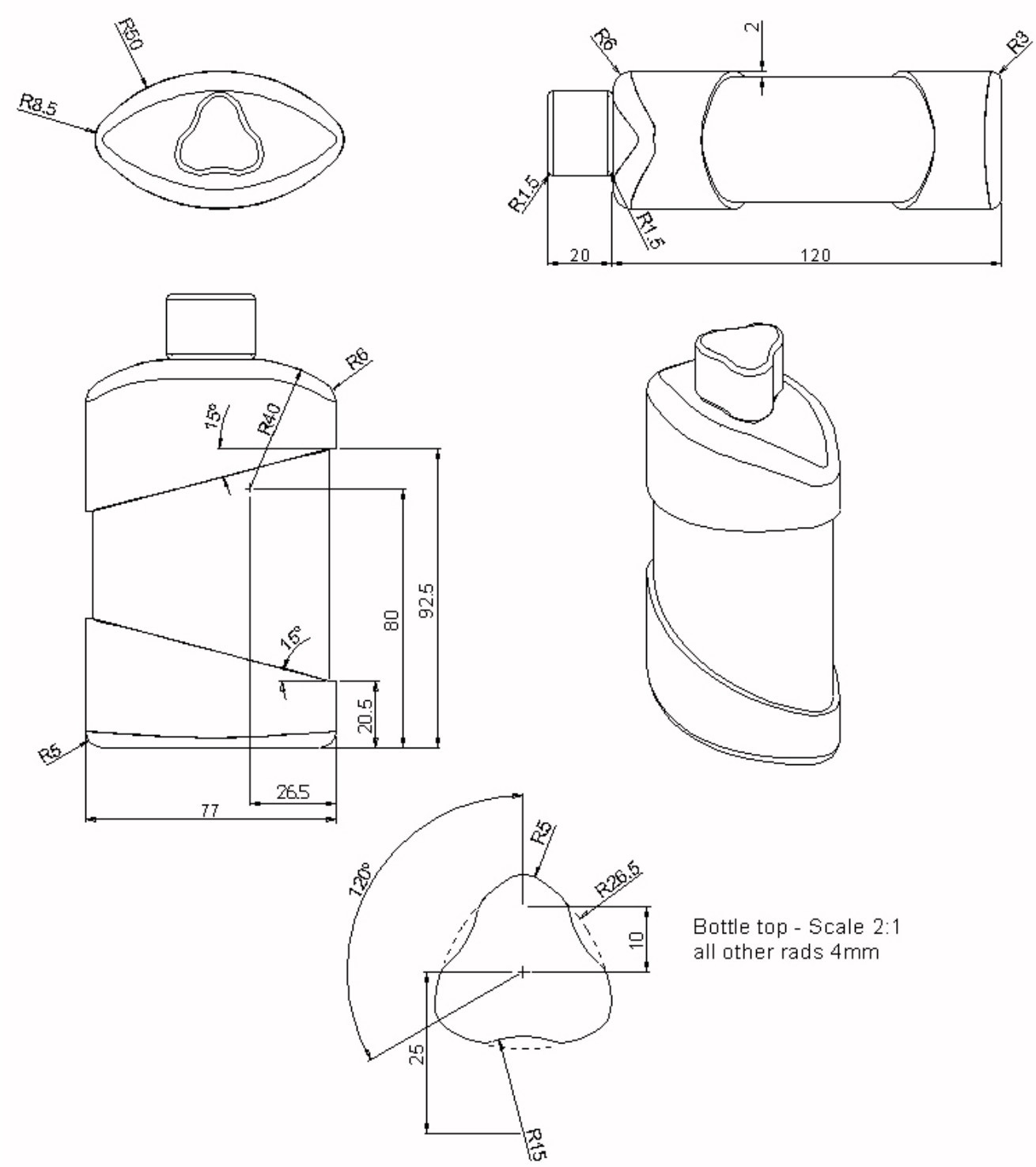
Model the radiator component.



Keyboard Button

Model the surfaces to form the keyboard button shown below. The button has a winding angle along one edge, which can be difficult to visualise. It is a constantly changing angle from one edge to the other.



Shampoo Bottle

The shampoo bottle shown has a **variable radius fillet blend** at the base.