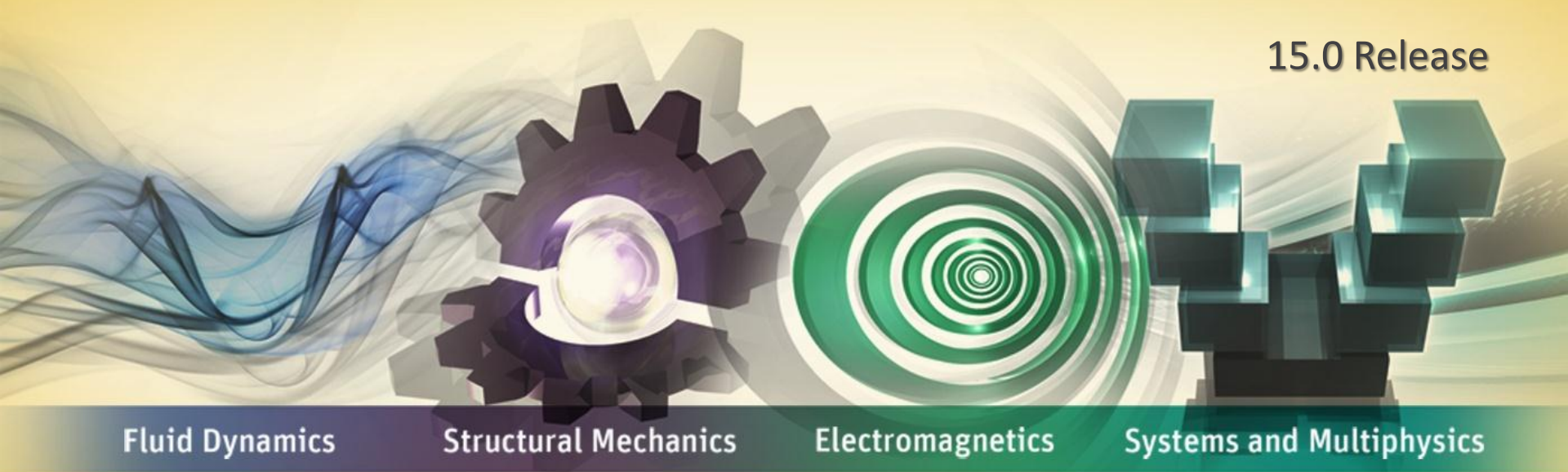


Workshop 2.1

Geometry Repair – Engine Block

15.0 Release

A horizontal banner with a yellow background. It features four distinct 3D visualizations: blue fluid flow lines on the left, a purple gear with a glowing center, a green concentric circle pattern, and a stack of teal cubes on the right. Below these images is a dark teal bar containing four white text labels.

Fluid Dynamics

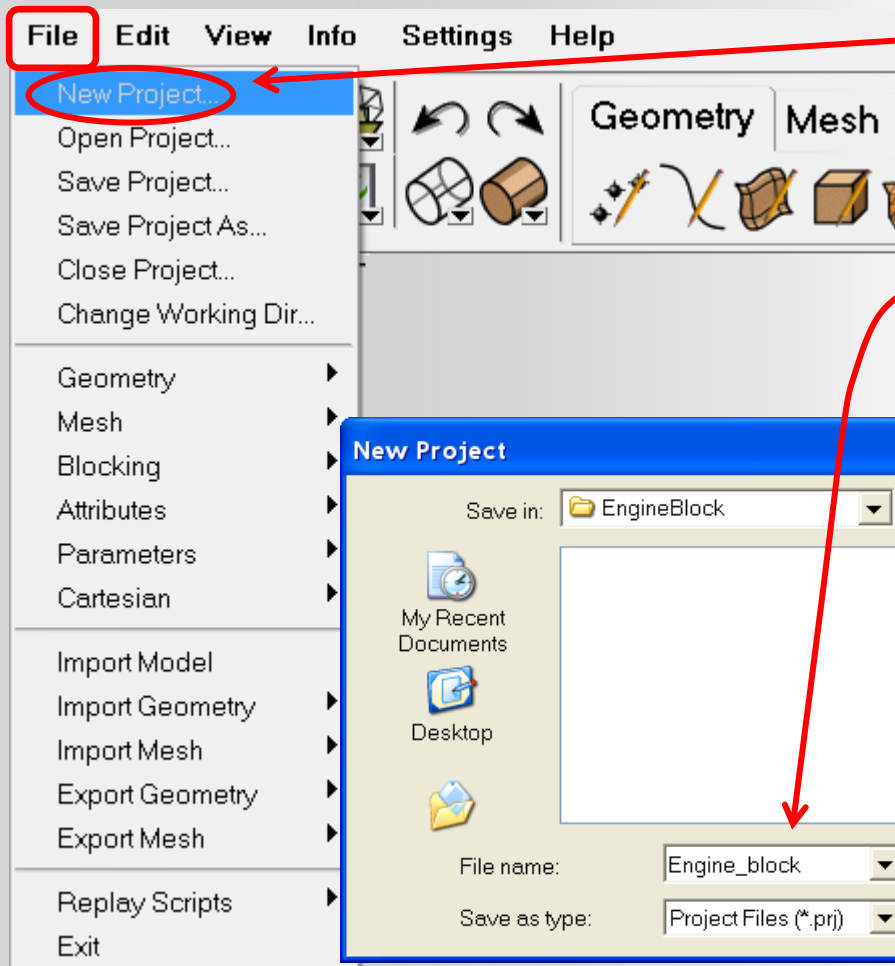
Structural Mechanics

Electromagnetics

Systems and Multiphysics

Introduction to ANSYS ICEM CFD

Create a Project



- Choose **File > New Project**
- Browse to **EngineBlock** working directory
- Enter the project name
- Type in the File name as: **Engine_block.prj**
- **Save**

Tips:

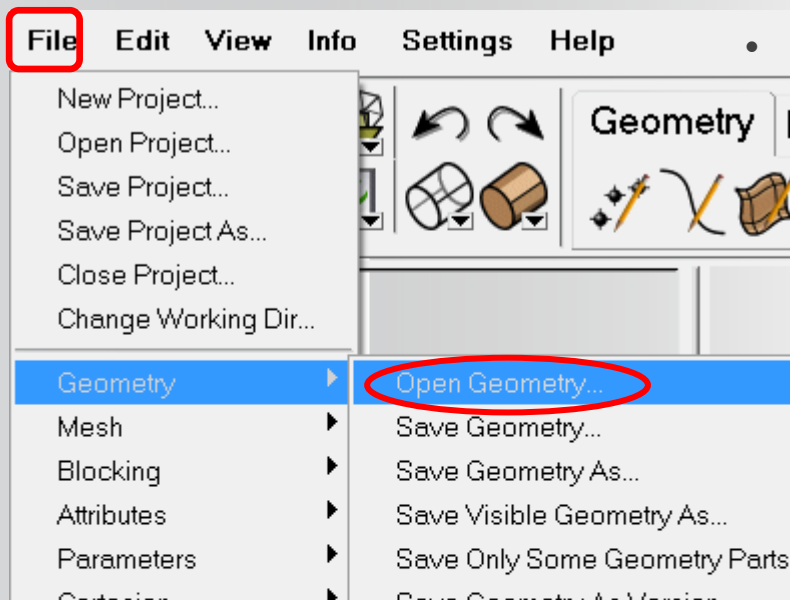
The pull down next to the file name can be used to quickly locate recently used projects.

In Windows, The File browser is a standard Windows file browser offering all the functionality of windows explorer.

In Unix or Linux, similar functionality is also available.

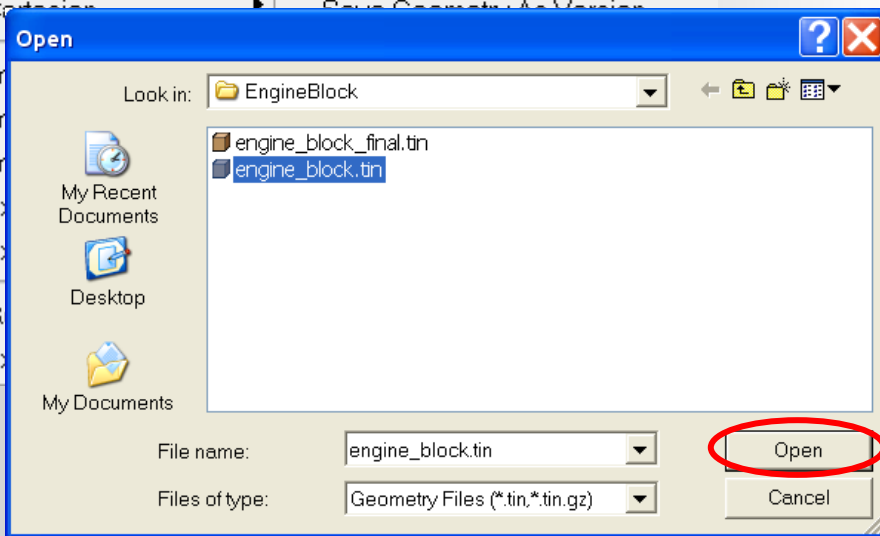
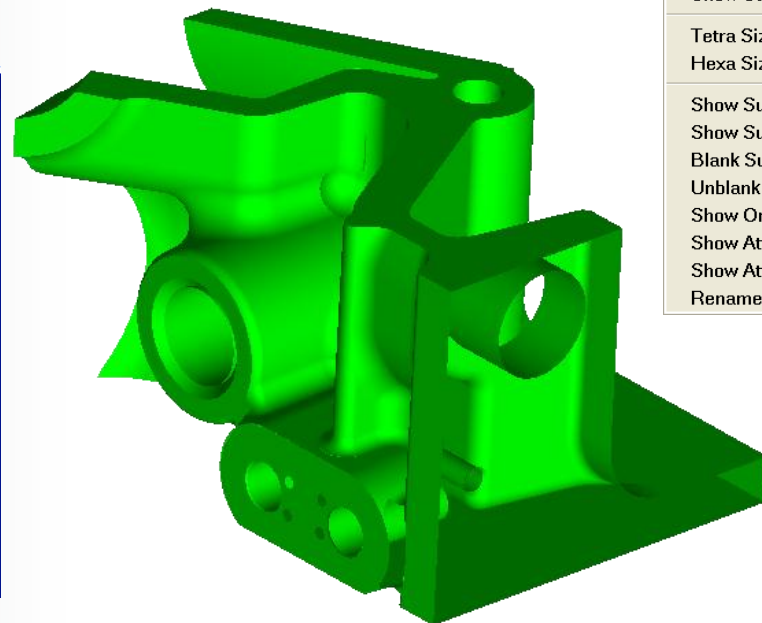
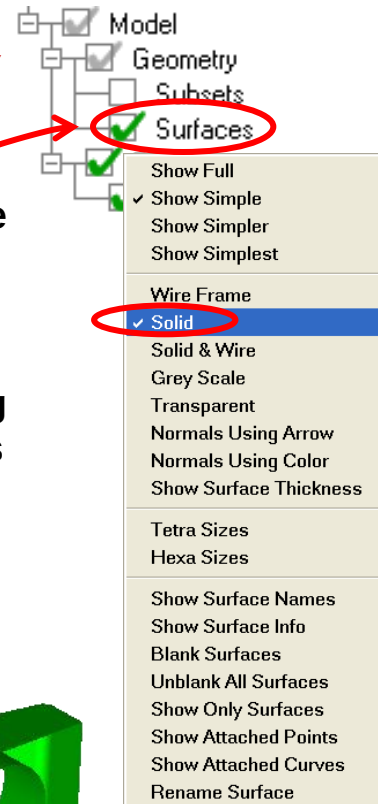
The **Project file** contains information about project settings, the working folder and file associations. The geometry, mesh, boundary conditions, parameter files etc. are saved with the project file. Simply loading the project file will also load these associated files.

Open Geometry

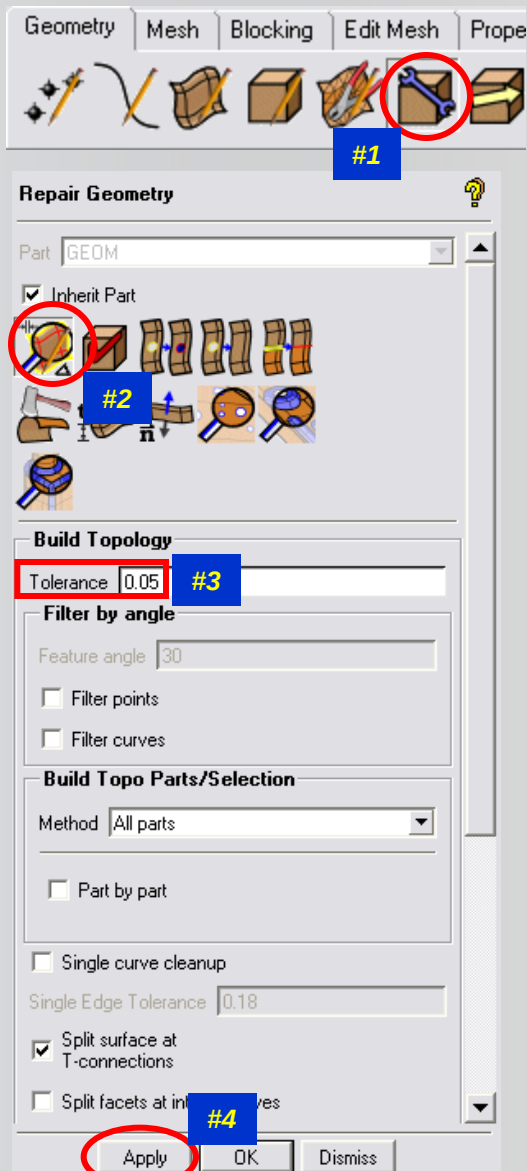


Read in the geometry:

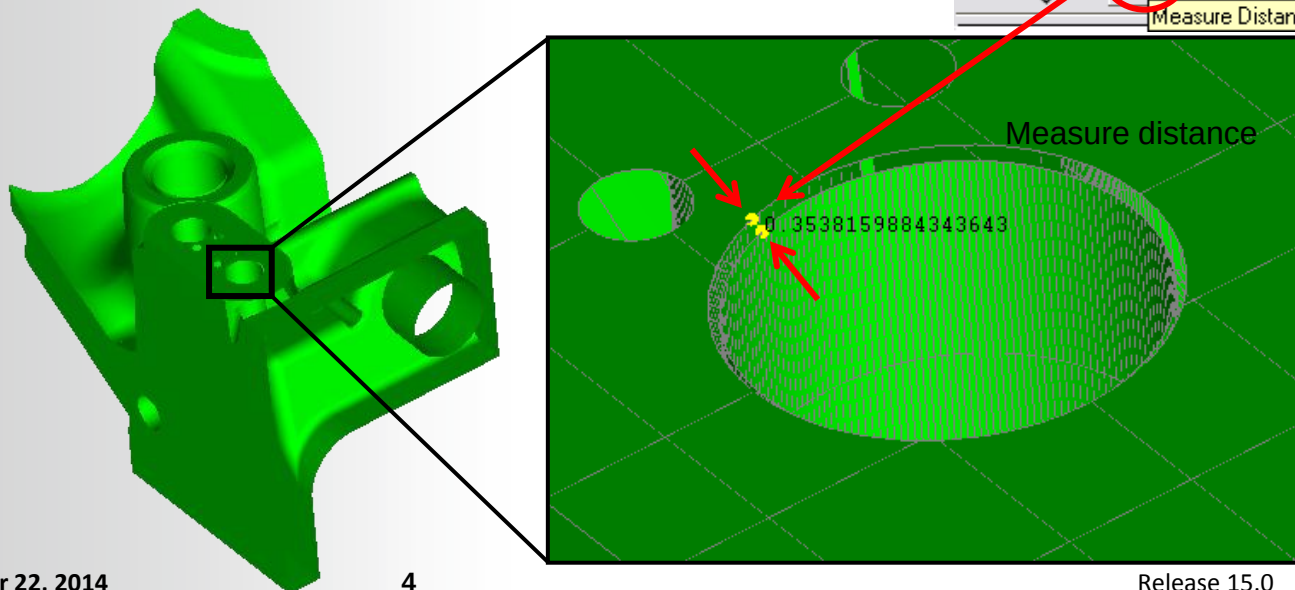
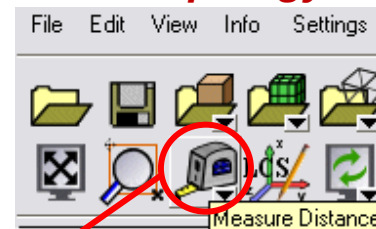
- **File > Geometry > Open Geometry**
- Select: **engine_block.tin** using the File Browser and **Open**
- **RMB** on surfaces in the Model tree and select **Solid**
- Rotate the model and you can see that this geometry has missing surfaces, holes, gaps, overlapping surfaces, and untrimmed surfaces



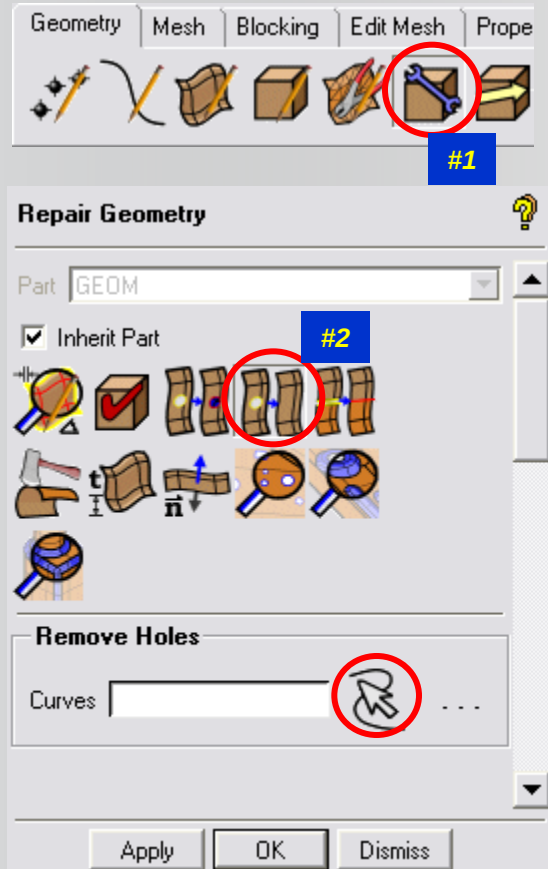
Build Diagnostic Topology



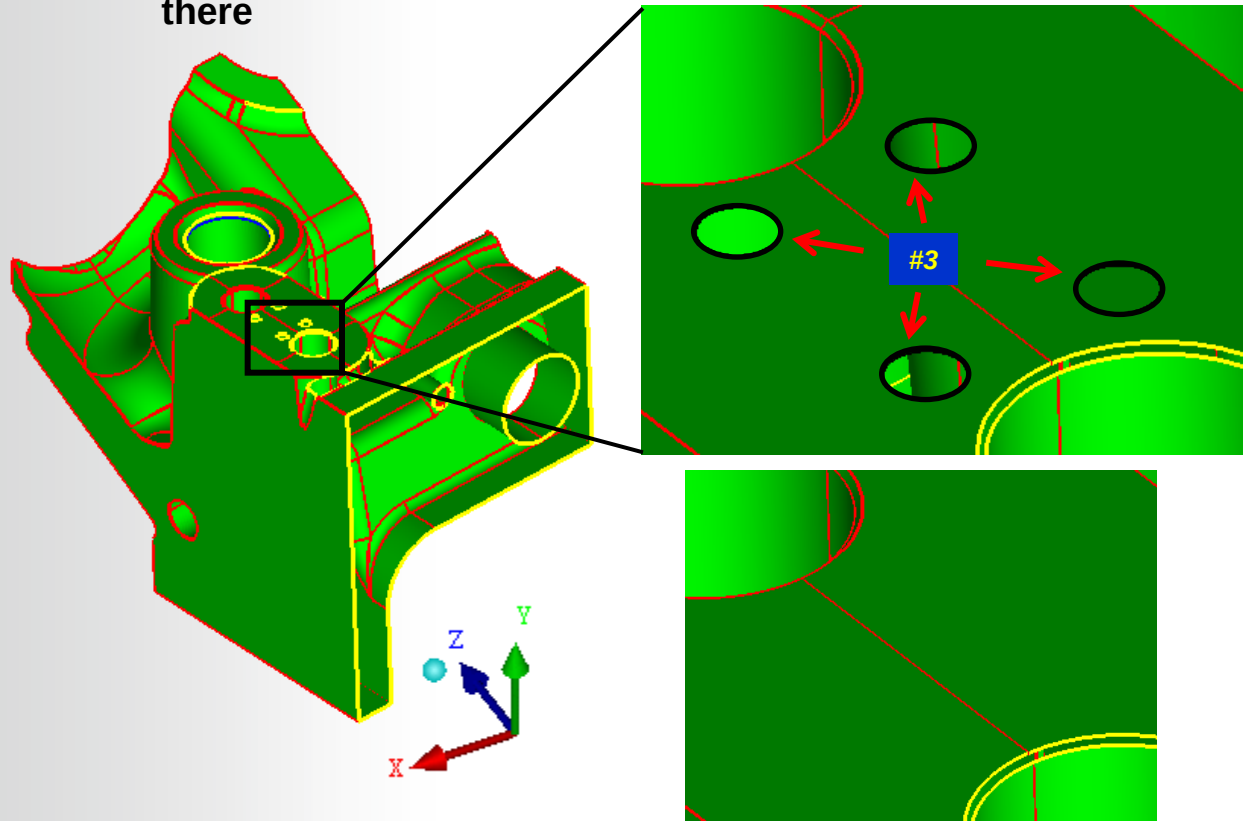
- **Build Diagnostic Topology** checks the geometry for imperfections within a user defined tolerance. Measure the size of the smallest feature on the geometry or any visible gaps. Make sure that the tolerance is small enough to keep important details in the geometry. Rule of thumb: 1/10th to 1/5th of the smallest mesh size, or 1/10th of the smallest geometry feature
- **Geometry > Repair Geometry > Build Diagnostic Topology**
 - Set **Tolerance = 0.05**
 - Accept all other defaults
 - Click **Apply**



Remove Holes

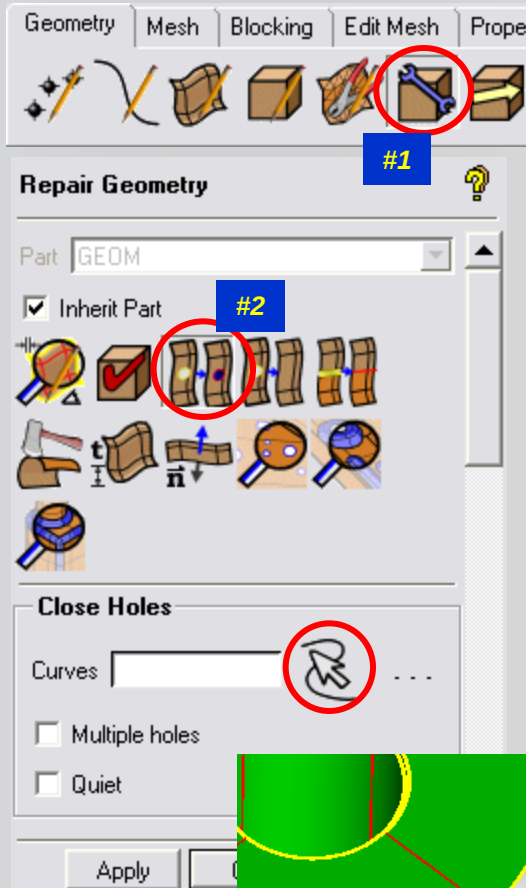


- Yellow curves indicate a gap or hole
- **Geometry > Repair Geometry > Remove holes**
 - Select the four boundary curves on the holes shown
 - **Middle mouse click**, and this will perform the function
 - Automatically removes holes by untrimming the surface there



Close Holes

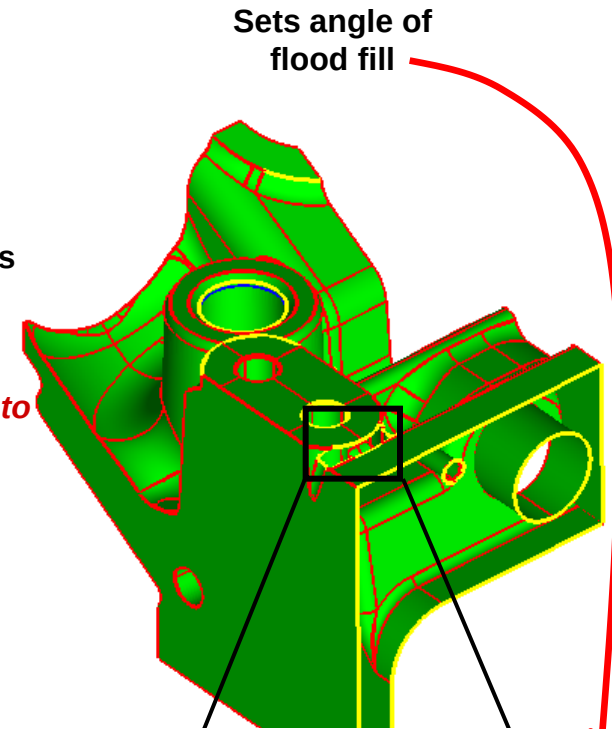
- **Geometry > Repair Geometry > Close holes**



Confirm with key 'y'

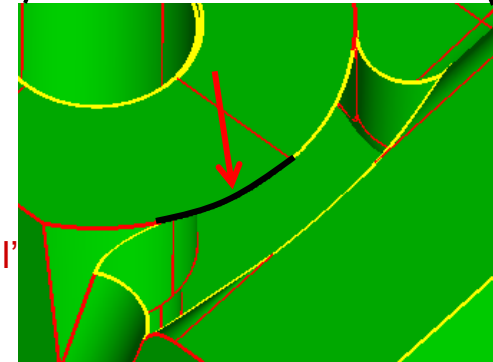
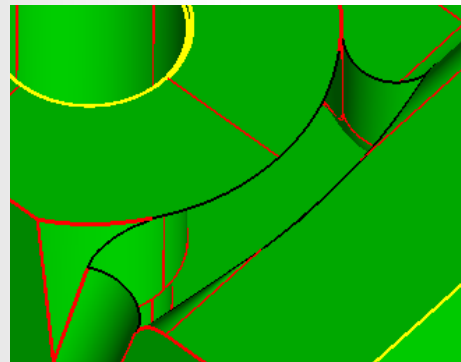
Option: y = yes; n = no.

- Select any one of the boundary curves on the hole shown
- Press "l" (lower case L) on the keyboard or **Select all items attached to current selection** in the **Select geometry** toolbar
 - Selects all curves within a set angle attached to the selected curve ("flood fill")
 - Selection restricted to yellow (single edge) curves
- **Middle mouse** to accept
- Press "y" to accept the surface
- **Middle mouse** to exit selection



← Middle mouse

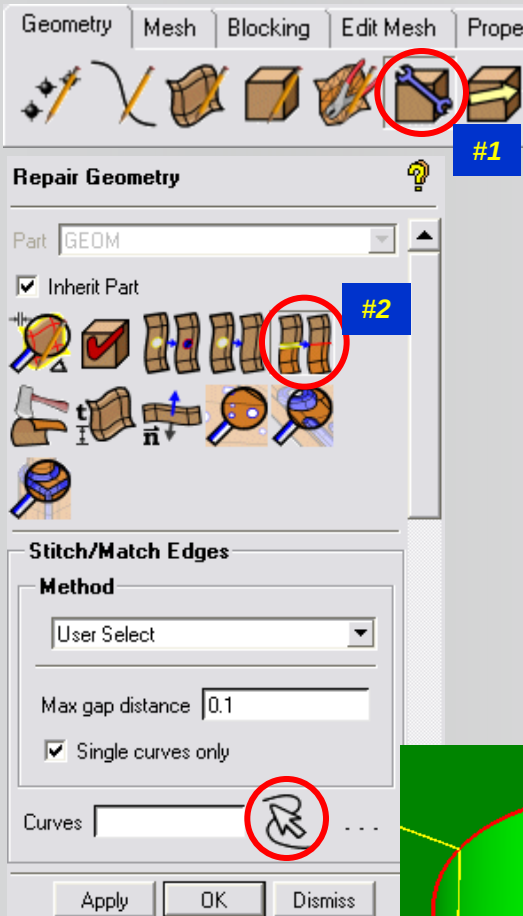
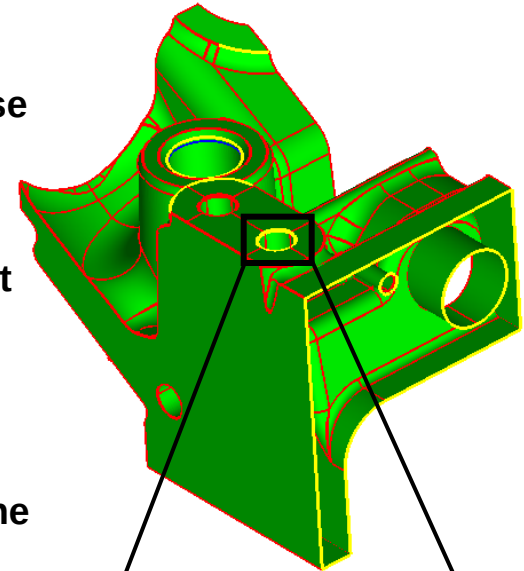
← Key 'l'



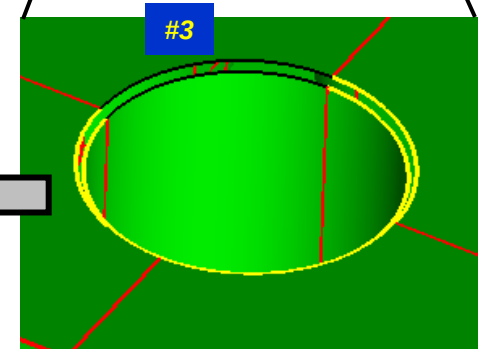
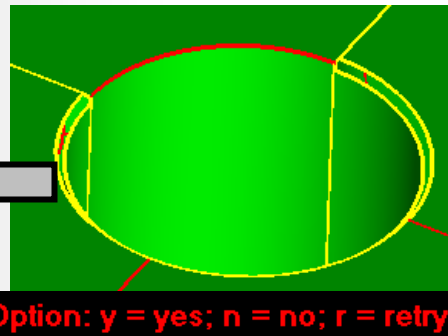
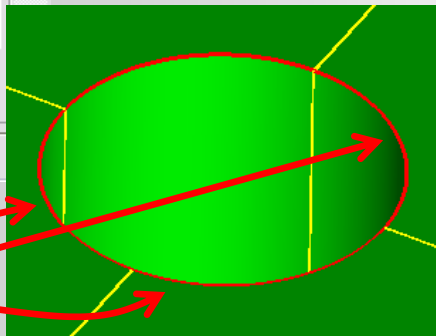
Stitch/Match Edges – Extend

- **Geometry > Repair Geometry > Stitch/Match edges**

- Select two opposite curves to close the gap in the location shown
- **Middle mouse** to accept
- When prompted press “t” to select trim
- Press “y” to accept, if it looks correct
- Repeat for 3 more pairs to close the gap. Middle click when done.
- Rerun **Build Topology** in order to update the connectivity (tol=0.05)



3 other pairs were done



Option: y = yes; n = no; r = retry.

Option: n = no change; f = fill; b = blend; t = trim; m = match; a = auto; x = cancel; p = set partial.

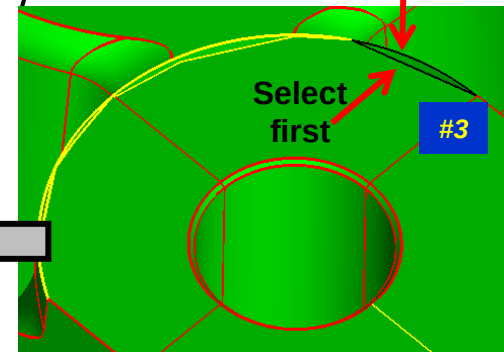
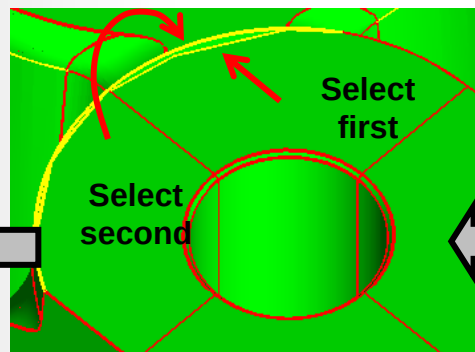
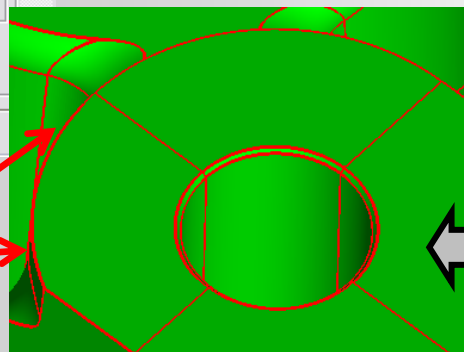
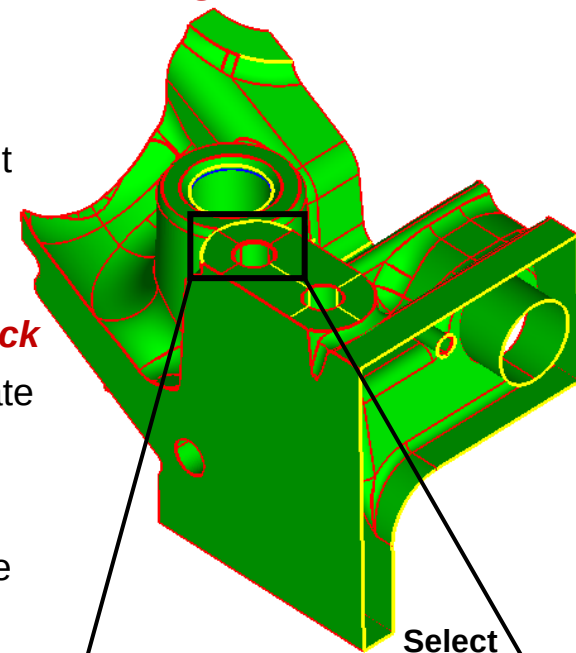
Stitch/Match Edges - Trim



2 more curve pairs were done here

• **Geometry > Repair Geometry > Stitch/Match edges**

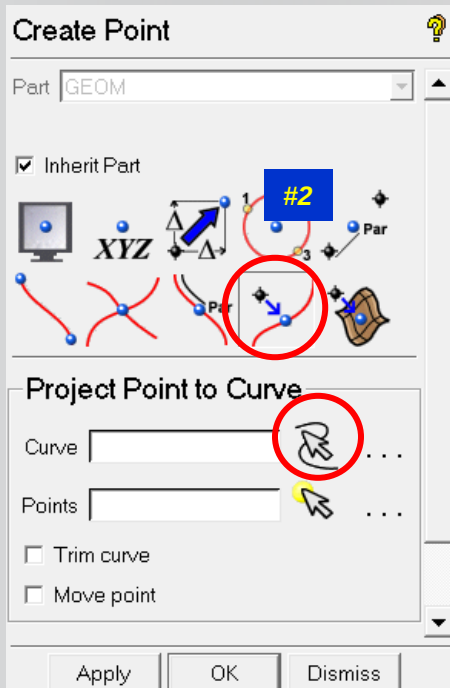
- Change method to **Extend/Trim**
- This is the same method as previously by pressing “t” with ‘**user select**’, but without confirmation
- Select the first 2 curves as shown at the lower right picture, and **middle mouse click**
- Rerun **Build Topology** (tol=0.05) to update the connectivity if any of these curves turn green (unattached)
- Order is important: first curve tries to move to second curve
- Repeat for a total of 4 pairs of yellow curves



Project Point to Curve

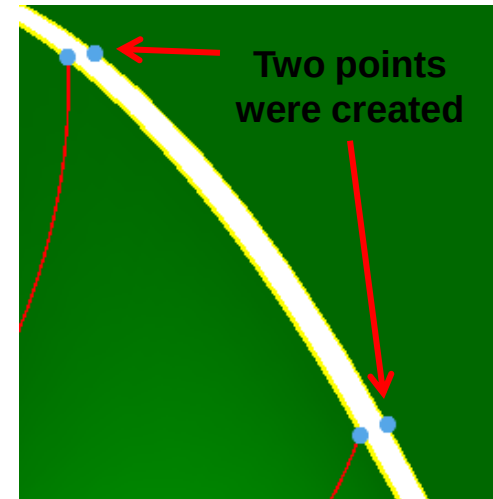
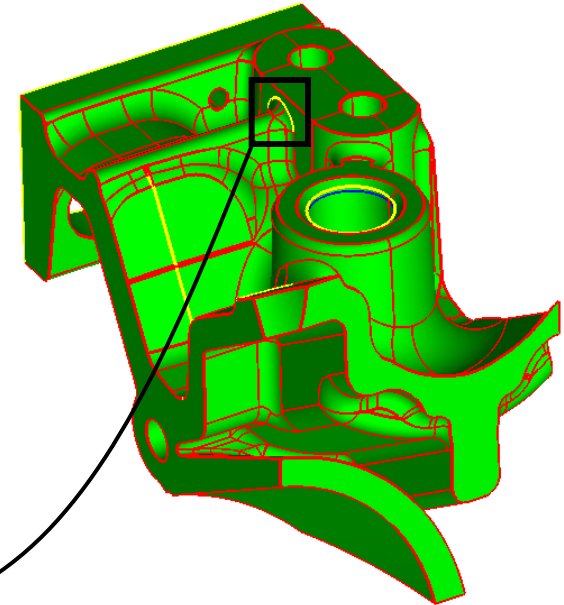
- **Geometry > Create point > Project Point to Curve**

- This location is similar to what is seen with IGES import often
- The surfaces will next be matched which will bend the surface of the first curve to match the second curve. Therefore, the curve ends must be fairly close or else the surface gets greatly distorted
- The large curve will need to be segmented at these points



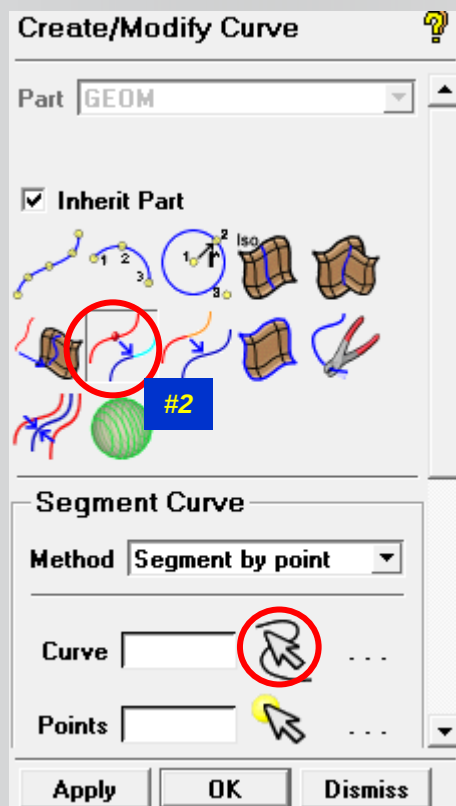
First select the long curve

Then select these 2 points and **middle mouse click twice** (2nd time exits selection)

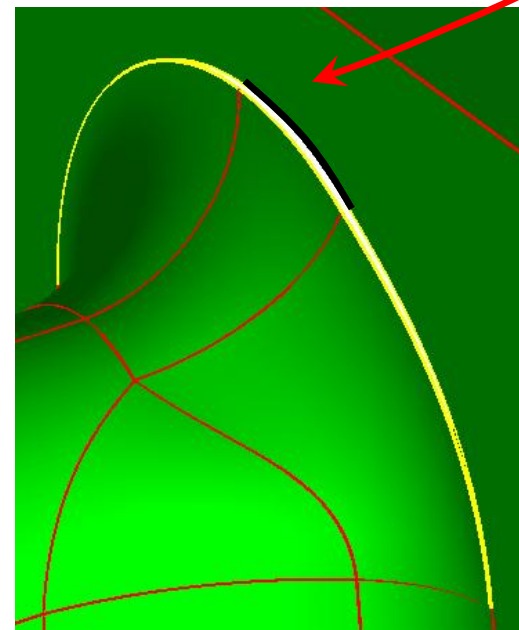
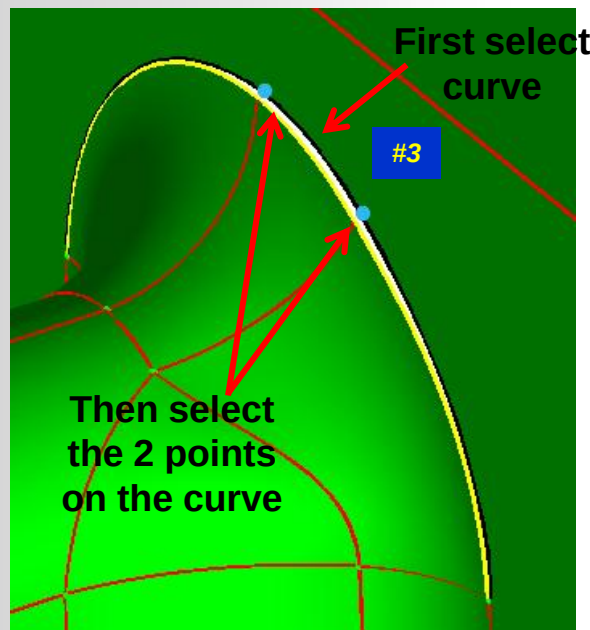
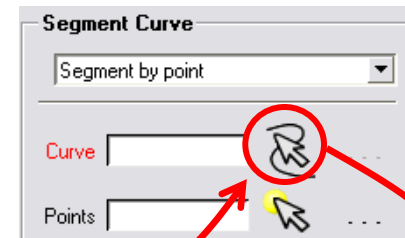


Segment Curve

- **Geometry > Create/Modify Curve > Segment Curve**

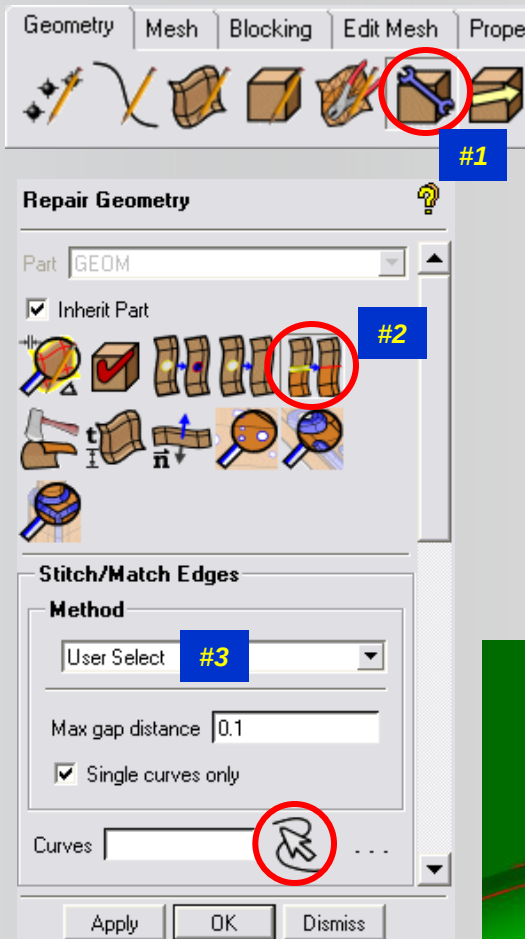


- Method = **Segment by point**
- Pick the long curve first
- Then select the two points on the curve
- **Middle mouse** click to finish
- Any function that highlights a curve will show it is segmented
- Right click to cancel

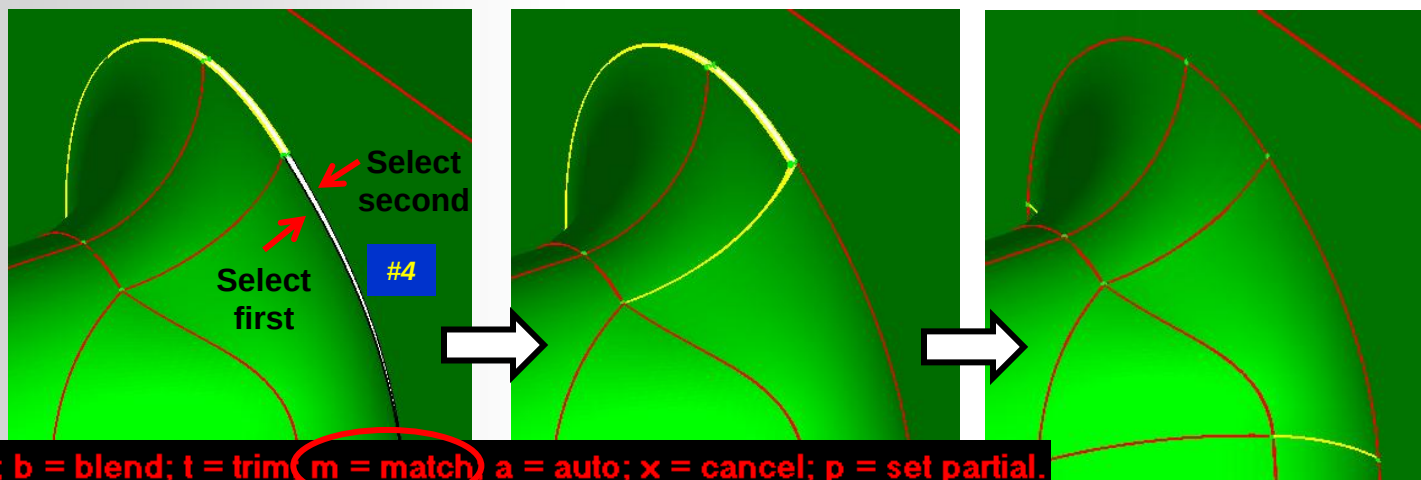


Stitch/Match Edges – Match

- **Geometry > Repair Geometry > Stitch/Match edges**

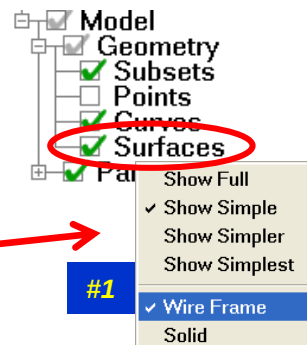


- Set **Method** back to **User Select**
- Select two opposite curves to match the surface boundaries as shown below, and **middle mouse** click.
- If you get an error, “**can't get endpoints of curve**,” build topology again
- Increase the value of “**Max gap distance**” to 0.2 if it doesn't work with value 0.1
- When prompted press “**m**” to select match
- The surface of the first curve will be stretched to meet the second curve
- Repeat for 2 more pairs to close the gap
- Rerun **Build Topology** in order to update the connectivity



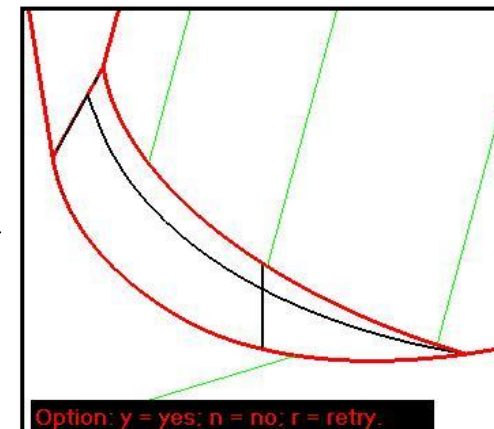
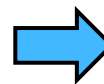
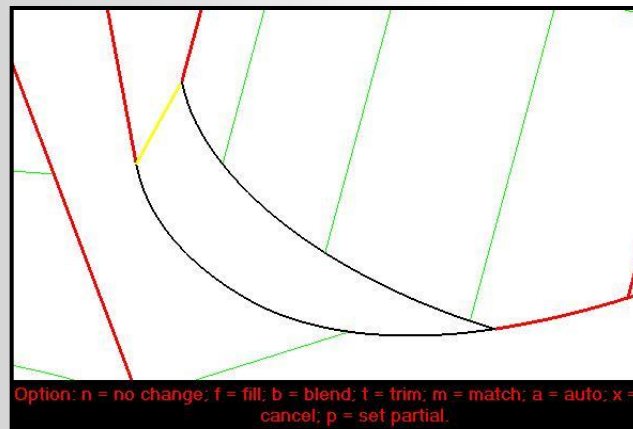
Option: n = no change; f = fill; b = blend; t = trim **m = match**; a = auto; x = cancel; p = set partial.

Close Gaps



Geometry > Repair Geometry > Stitch/Match edges

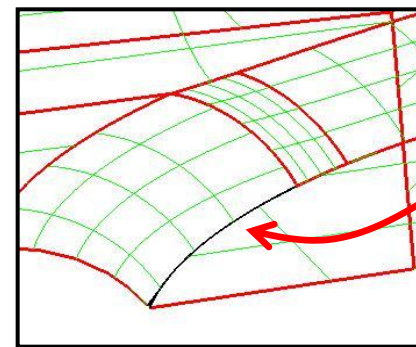
- First change surface display to wireframe
- Set **Max gap distance** to **2.0**
- Select all curves (box select and **middle mouse** or press **"a"**)
- Each single curve pair within the defined gap distance will be presented automatically. Choose the option "fill," key **"f"** and confirm with **"y"**. For example:



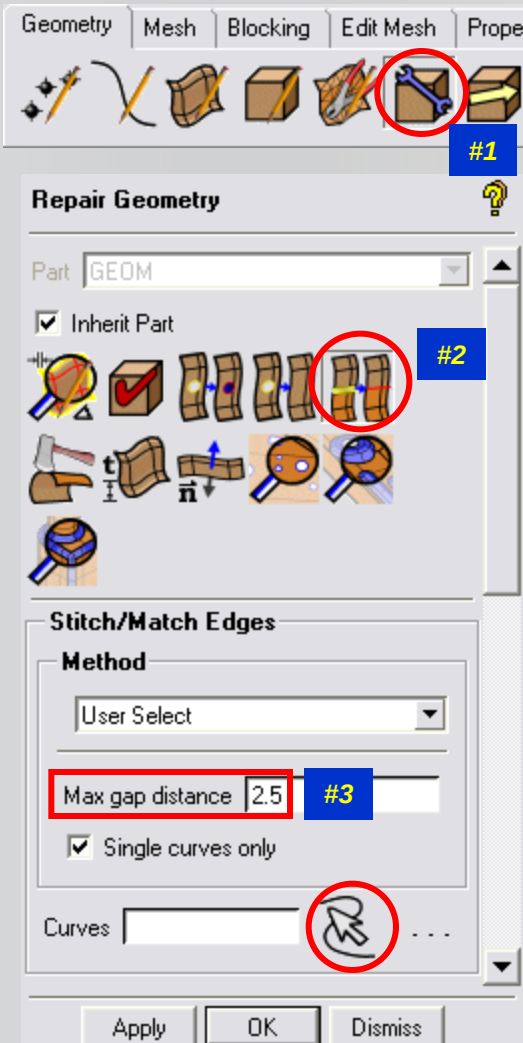
Skip very tiny gaps by the option **no change**: key **"n"**. For example:

- **Middle mouse click** when done

In this workshop you will have to use the fill option to create five surfaces and ignore two tiny gaps using no change option

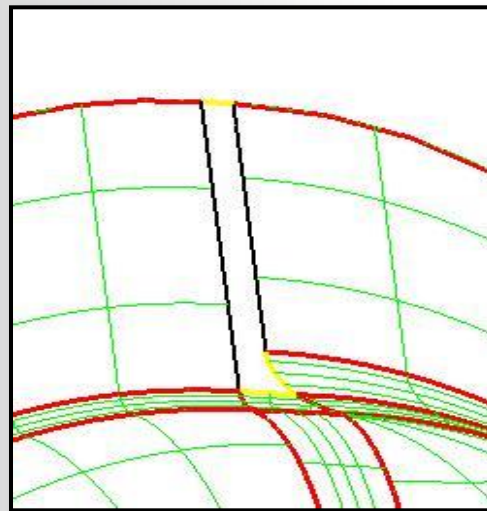


Close Gaps

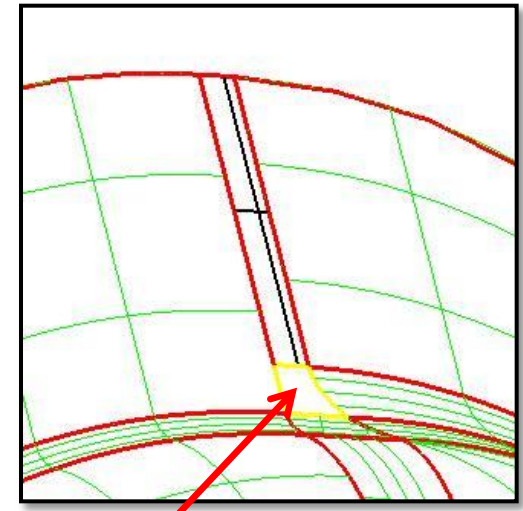


Increase the gap distance to 2.5, enter curve selection again and select all curves.

- **Geometry > Repair Geometry > Stitch/Match edges**
 - Set **Max gap** distance to **2.5**
 - Select all curves **"a"**
 - When presented, skip the 2 tiny gaps by option **"n"**, '**no change**', until a larger gap appears between a longer and a shorter curve. Use the option **'set partial'** - key **"p"**, and then **'fill'** - key **"f"**, confirm with **"y"**.
 - Use the option **'no change'**, **"n"** when presented with more curves, or **"x"** to cancel further curve pairs.

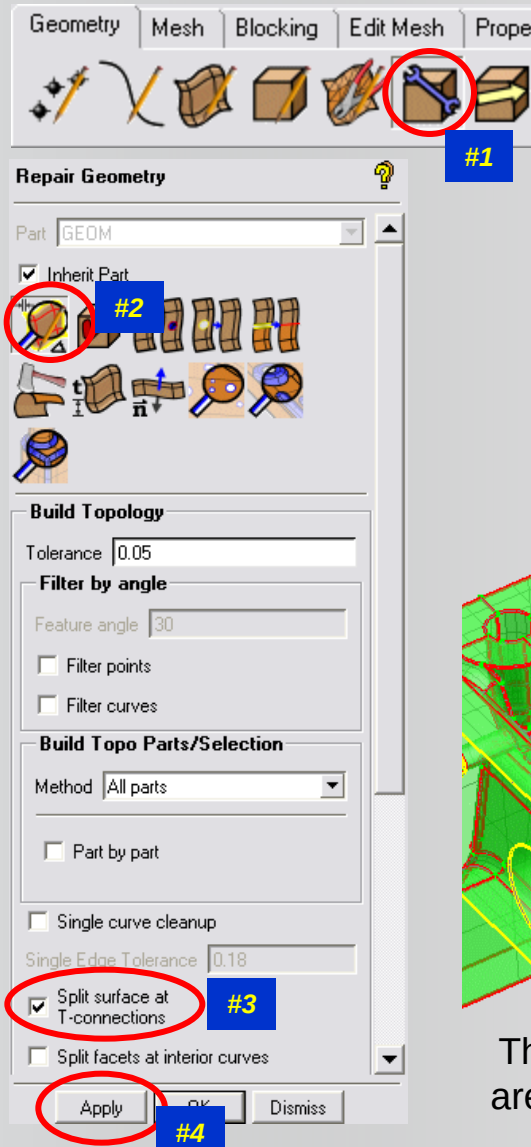


Press **"p"** for **'set partial'**
Then press **"f"** for **'fill'**

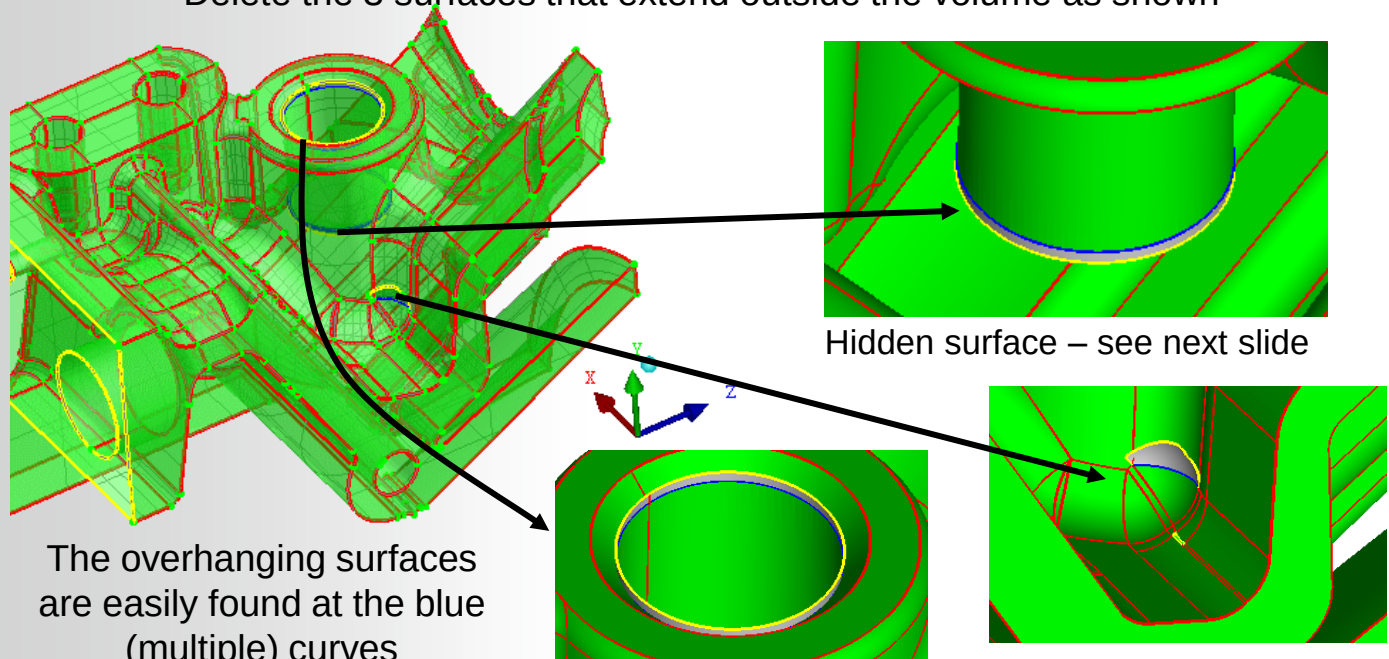


Do NOT fill this one. The wrong
curves will be highlighted

Build Topology: Split surfaces

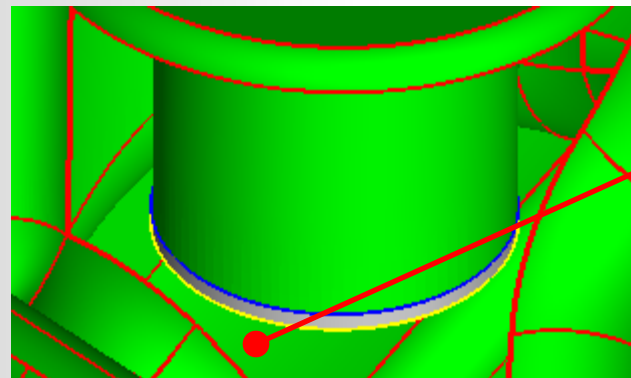
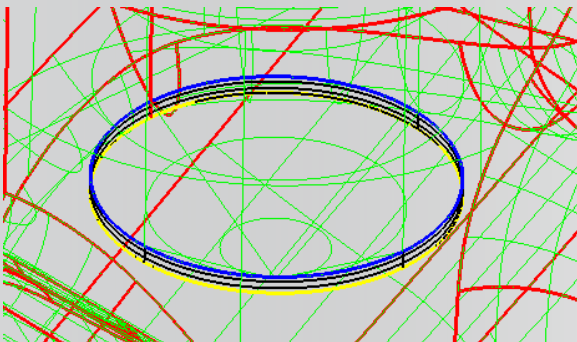
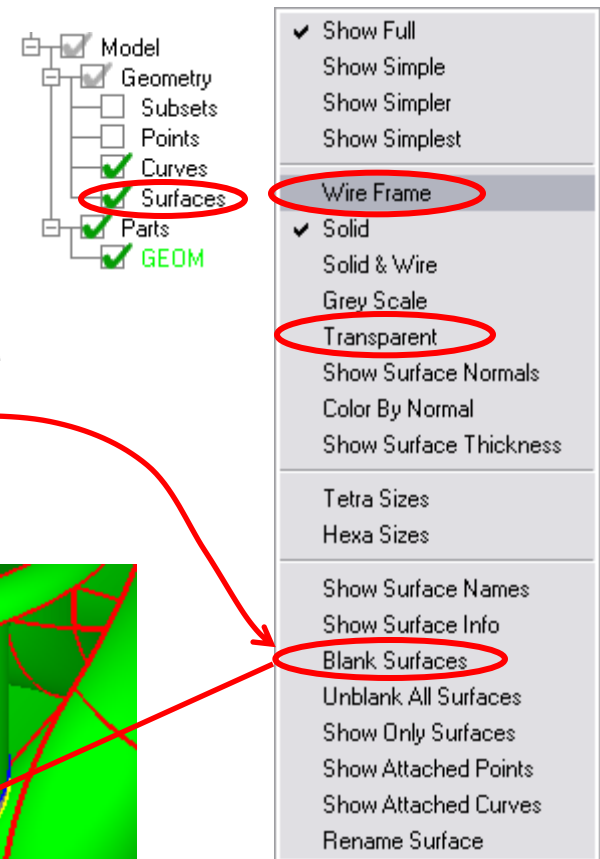


- Select **Geometry > Repair Geometry > Build Diagnostic Topology**
 - Keep **Tolerance = 0.05**
 - Toggle on **Split surface at T-connections** if it is not on already
 - Surfaces automatically trimmed
 - If build topology was already run with this option on then the surfaces are already segmented
 - Click **Apply**
- Delete the 3 surfaces that extend outside the volume as shown

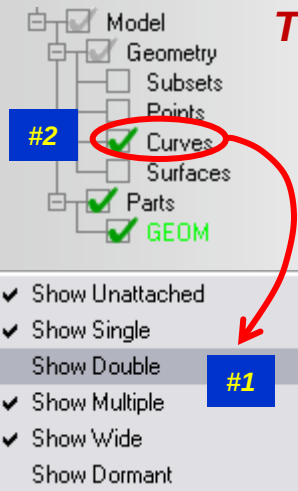
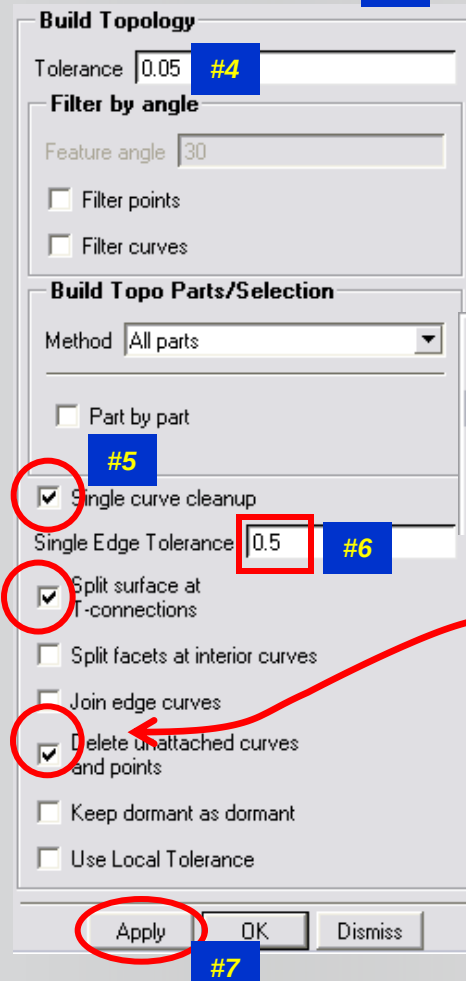


Delete Surface from Previous Slide

- To select surfaces in background
 - If hard to view “hidden” or background surface, turn on **Transparent** mode
 - RMB **Surfaces** in model tree
 - Can’t select “through” solid surface in foreground
 - Even when transparent
 - Turn on **Wire Frame**
 - You can select through foreground surfaces by selecting parametric line of background surface
 - Or blank surface in foreground in solid display
 - Then select interior surface to delete



Build Topology

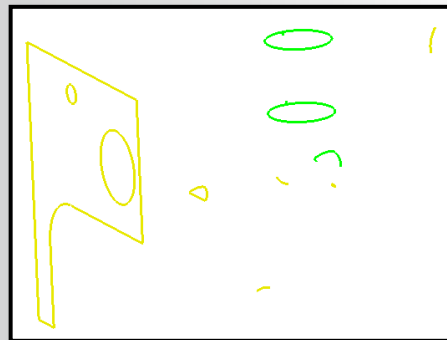


- RMB on curves and select **Show Double**. This will turn off all double (red) curves. Double curves are connected to 2 surfaces
- Turn off surfaces and points
- **Geometry > Repair Geometry > Build Diagnostic**

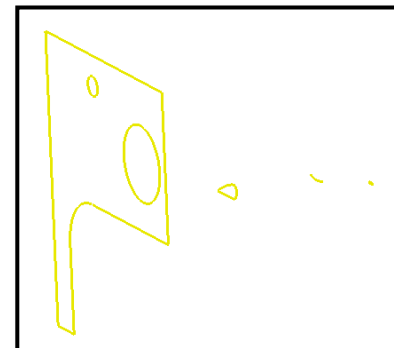
Topology

- Set **Tolerance = 0.05**
- Toggle on **Single curve clean up** and enter a tolerance of **0.5** (always a bigger number than the first tolerance)
 - Thin gap regions less than 0.5 will be ignored
 - Sliver features greater than 0.05 will be retained
- Toggle on **Split surface at T-connections** (if not ON)
- Accept all other defaults
- Press **Apply**

– Note unattached curves (green) are automatically deleted and some yellow curves disappeared



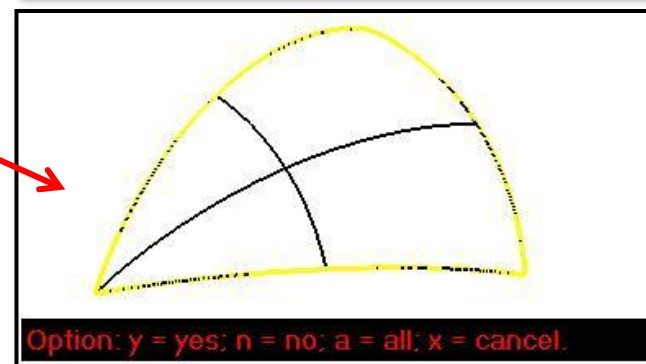
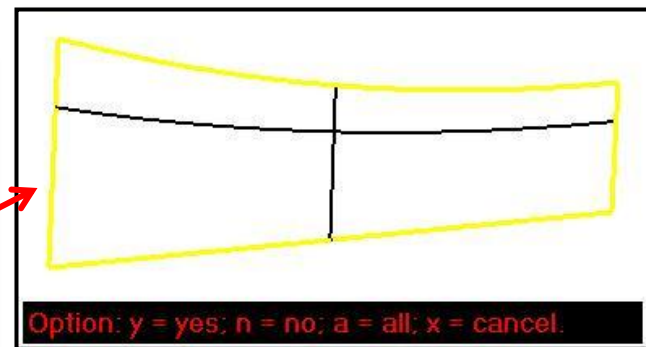
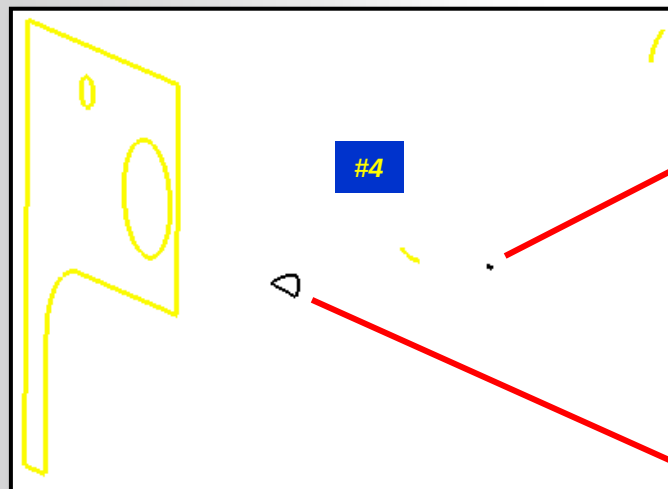
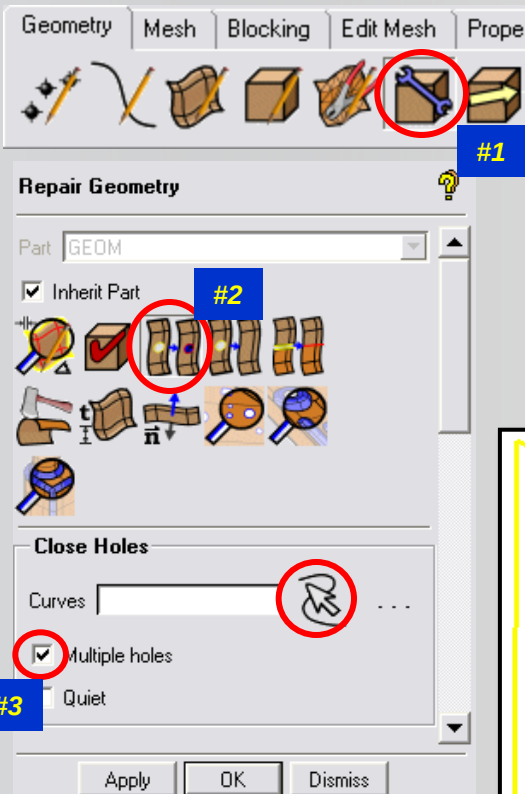
Build
topology



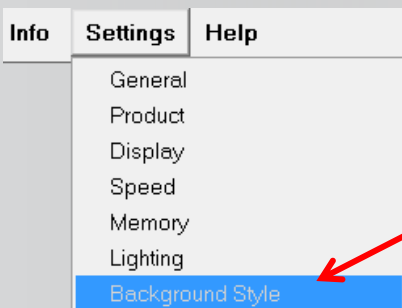
Close Holes

- **Geometry > Repair Geometry > Close Holes**

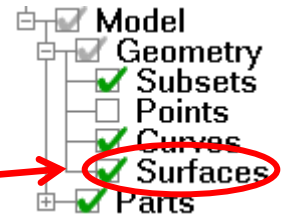
- Toggle on **Multiple holes**
- Box select the curves that bound the two holes shown and **middle mouse click**
- When prompted press “y” to accept each created surface
- **Middle mouse click** afterward to exit selection



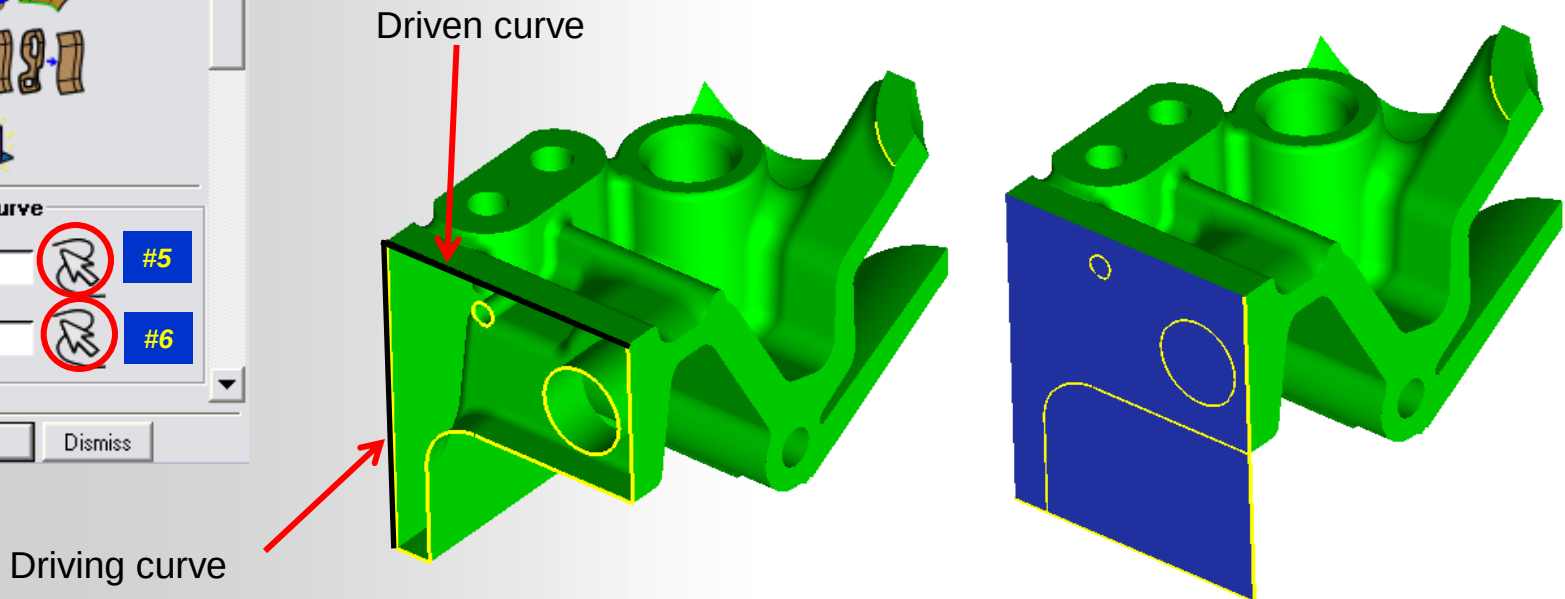
Make sure background is not white in order to see the highlighted surface,
Settings > Background Style



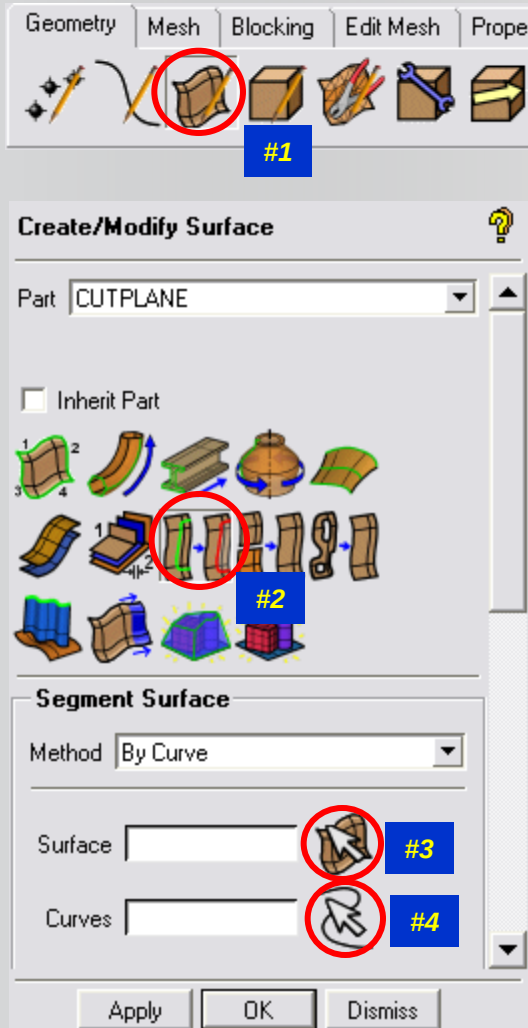
Create Surfaces



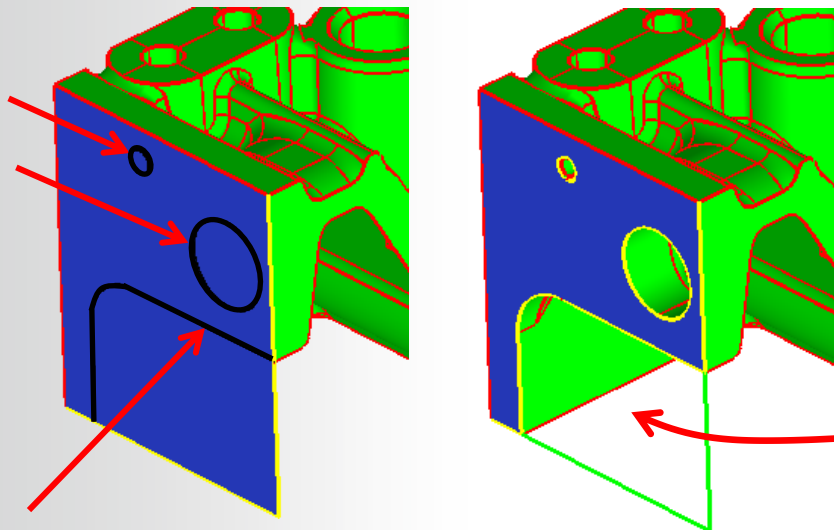
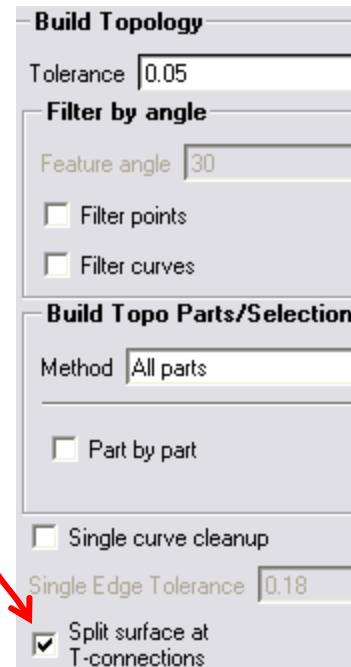
- First turn surfaces back on
- **Geometry > Create/Modify Surfaces > Curve Driven**
 - Turn **Inherit part** OFF
 - Enter the part name as **CUTPLANE**
 - Select the driving and the driven curve as shown
 - Only need to **middle mouse click** after driven curve
 - **Middle mouse click** again after the surface is created in order to exit selection mode



Trim Surface

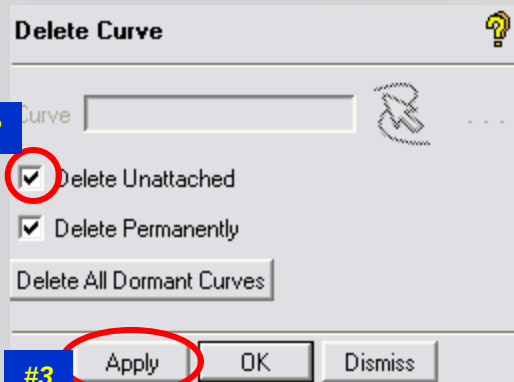
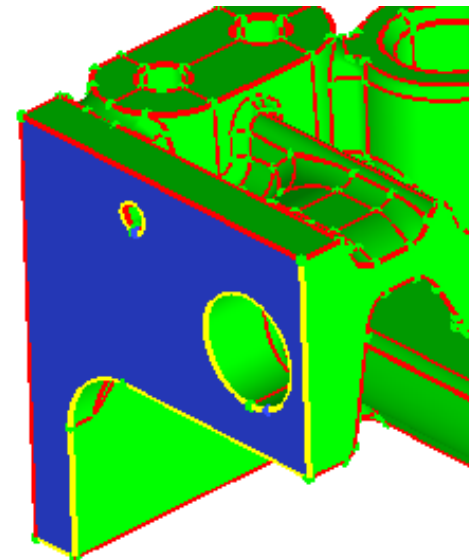


- **Geometry > Create/Modify Surfaces > Segment/Trim surface**
 - Select the CUTPLANE surface, **middle click**
 - Select the single curves (yellow) shown to trim the surface and **middle mouse click**
 - The surface is split into 4 separate surfaces
- The surface segmenting can also be done by running **Build Topology** with **Split surface at T-connections** toggled ON
- Delete the 3 unwanted surfaces afterward

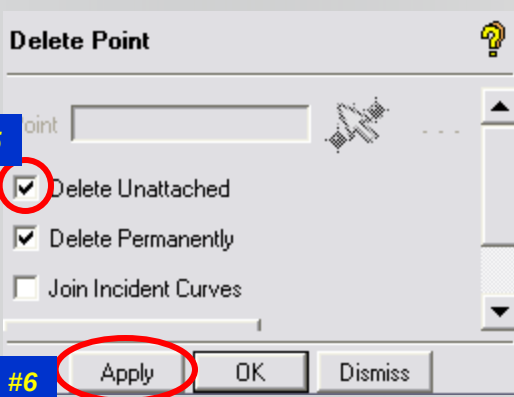


Delete surface

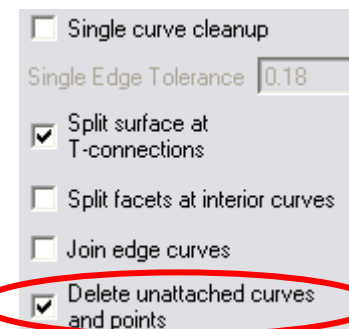
Delete Unattached



- **Geometry > Delete Curve**
 - Toggle on **Delete Unattached**
- No curves need to be selected. All unattached curves will be deleted
- Press **Apply**
- An unattached point is still left

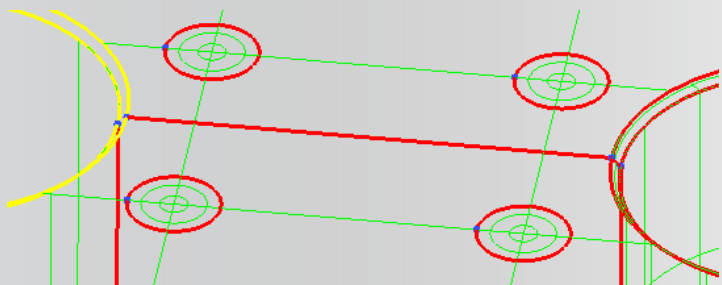


- **Geometry > Delete Point**
 - Toggle on **Delete Unattached**
- Press **Apply**
- Both these operations can be done by **Build Topology** with **Delete unattached curves and points**
- Save Project

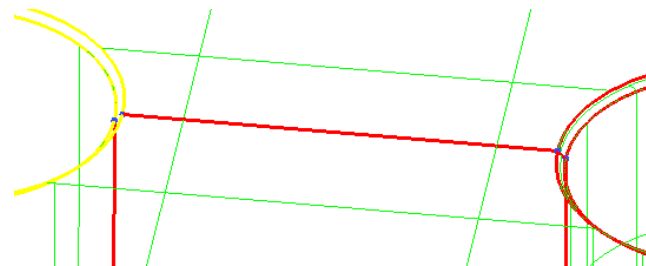


Further Investigation

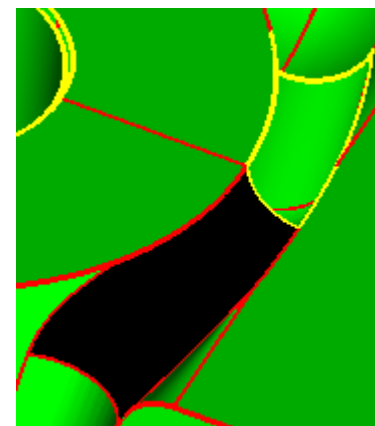
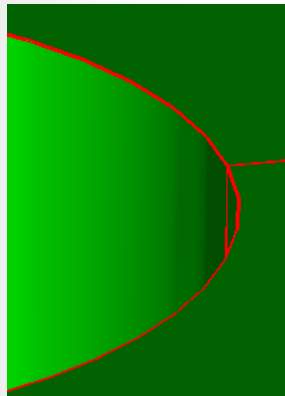
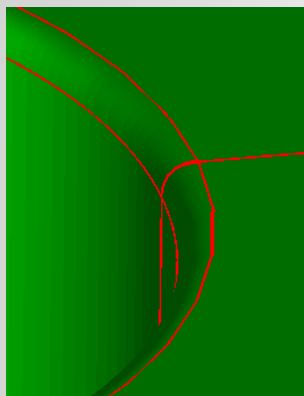
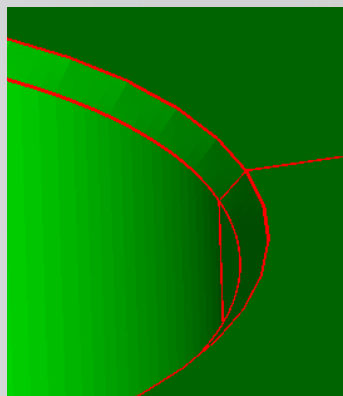
- For those that have the time, the following pages introduce additional concepts



Remove holes
instead of close
holes



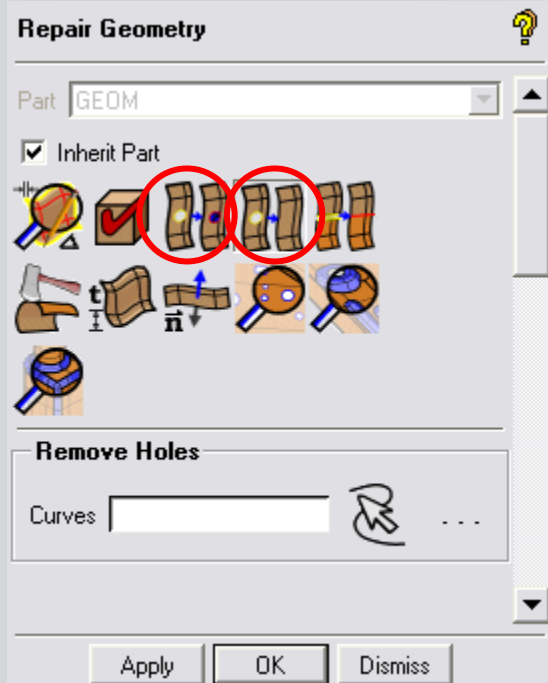
Other stitch methods



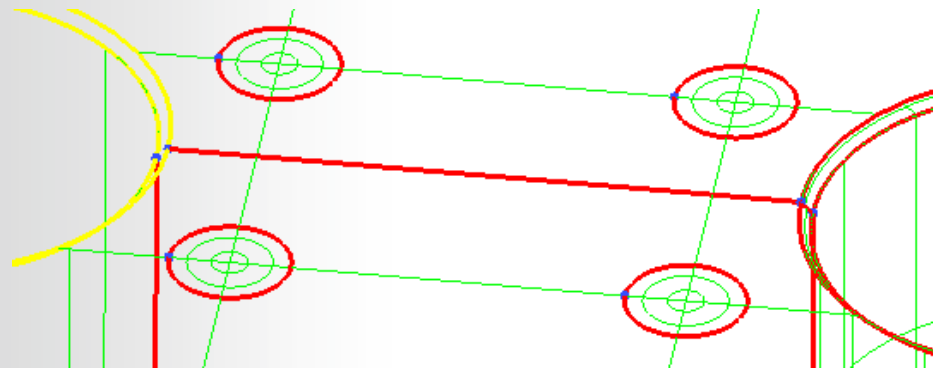
Manually make a better
shaped surface

Close/Remove Holes

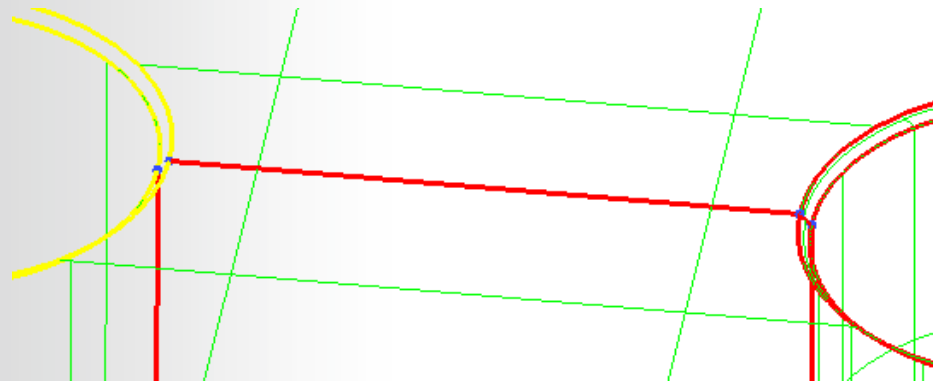
- Open the original geometry again, build topology, and try these further exercises
- Inspect the difference between using *close holes* and *remove holes*



- You will need to put surfaces in wireframe to see the difference



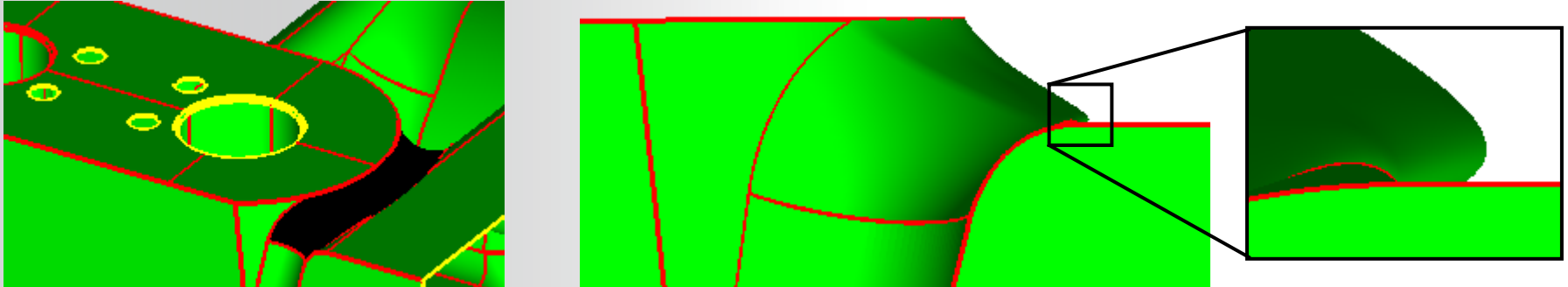
Close holes
fills with
new
surfaces



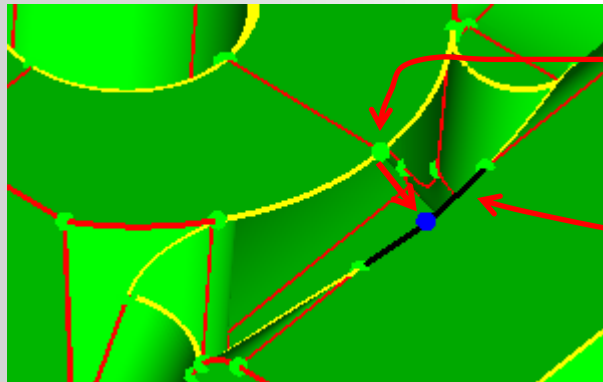
Remove holes
redefines
the
existing
surface

Close Hole with Better Shape

- View the filled surface carefully, and you will see a strange bump



- To get a better shape, you will need to fill this hole with multiple smaller surfaces and create a curve through the worst area to explicitly define the surface curvature there
- To do this, first project the point to the curve shown and then segment the curve.

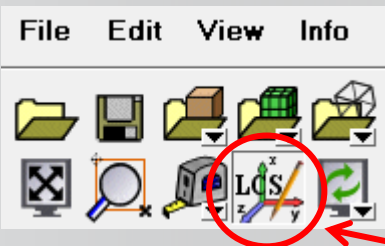


Project this point to this curve

Then segment the curve at the new point

Close Hole with Better Shape

- You will need to create a spline “*from points*” or a 3-point “*arc*”
 - You will have to select off geometry in space for one of the points, but selecting in space will select on one of the 3 base planes (XY, YZ, XZ) going through the origin
 - So this will require you to create a local coordinate system which defines new base planes



Define Local Coordinate System

Name: LCS1

Number: 1

Reference: Global

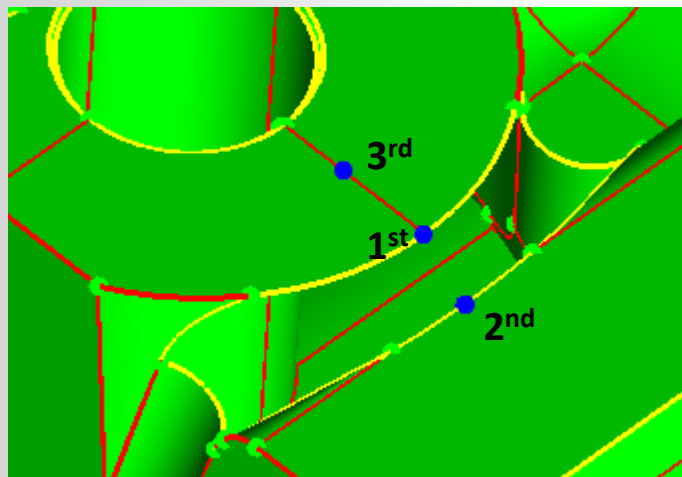
Type: Rectangular

Defined by: 3 Points

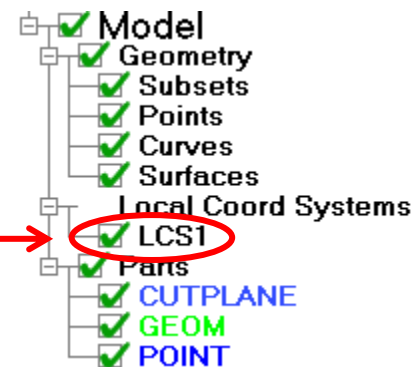
3 Points: [] [] []

Buttons: Apply, OK, Dismiss

- Use this icon to create a local coordinate system using the **3 point** method
 - 1st point is the origin, 2nd point is the Z axis, and the 3rd point defines the XZ plane (shown below)



The current local coordinate system is activated in the model tree

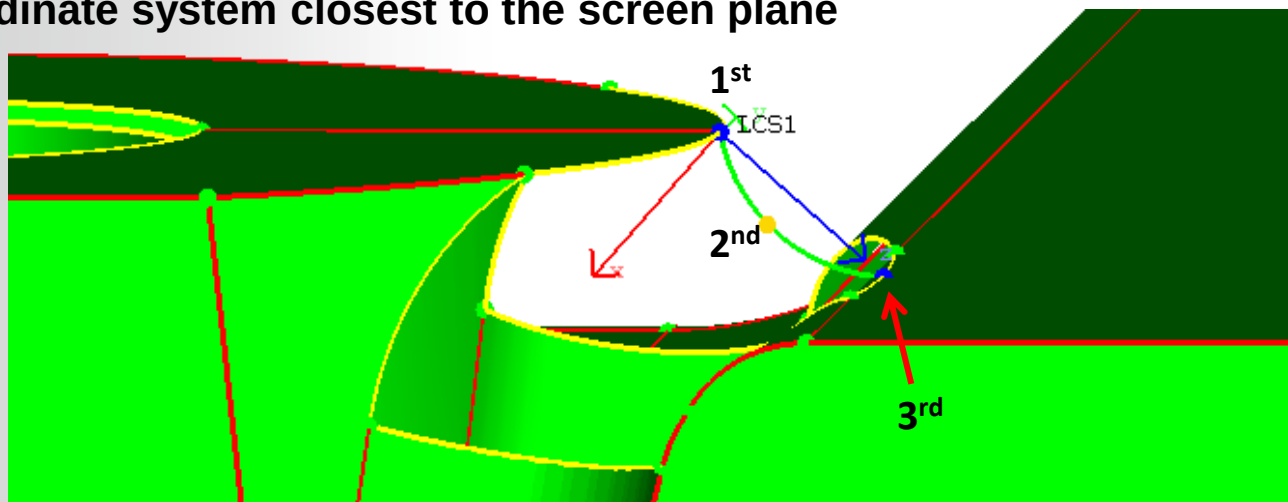
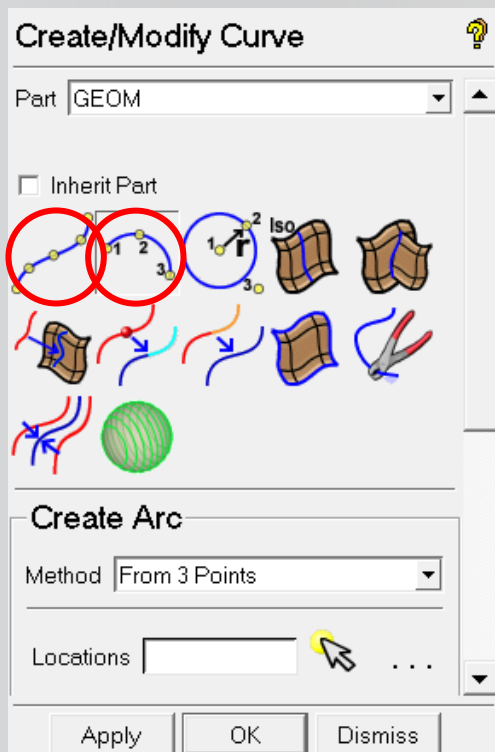


Close Hole with Better Shape

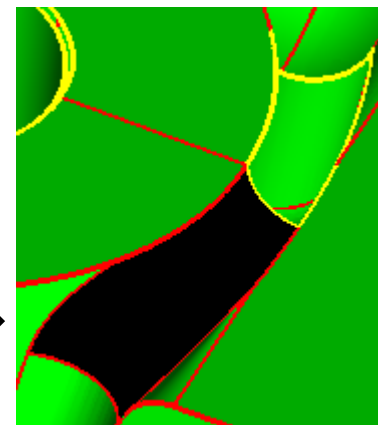
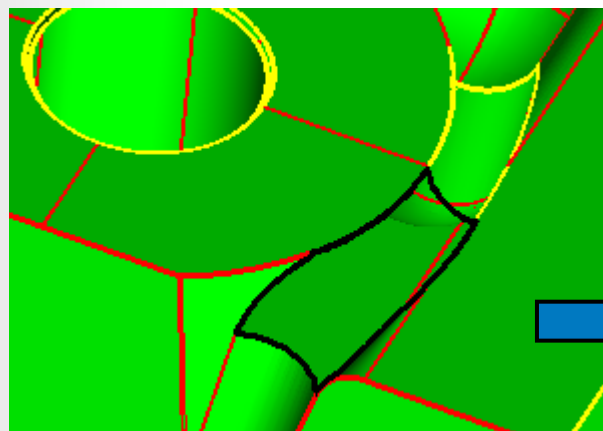
- Create a curve with the **“from points”** or **“arc”** method (investigate the difference)

- The yellow dot will jump to the nearest point when you select at the ends.

When you select in space for the middle location it will select on the base plane in the local coordinate system closest to the screen plane

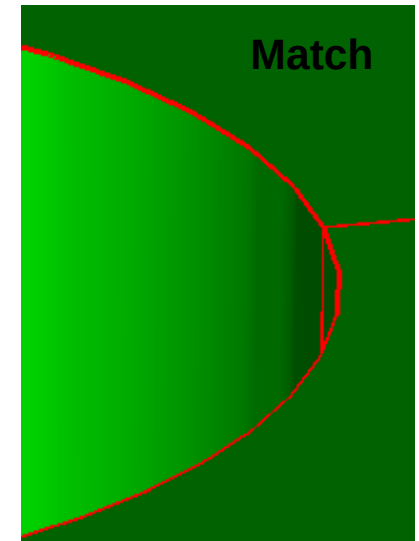
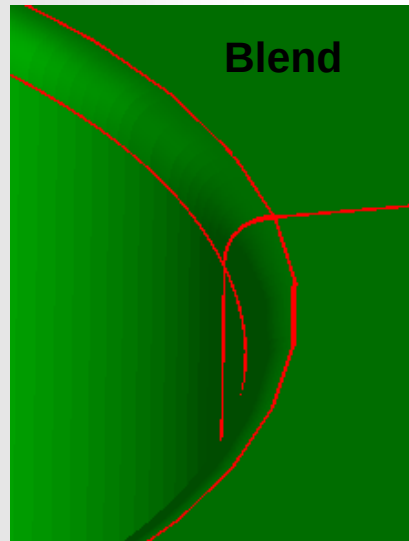
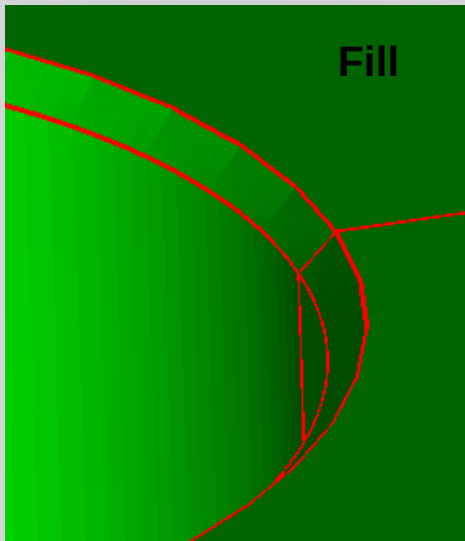
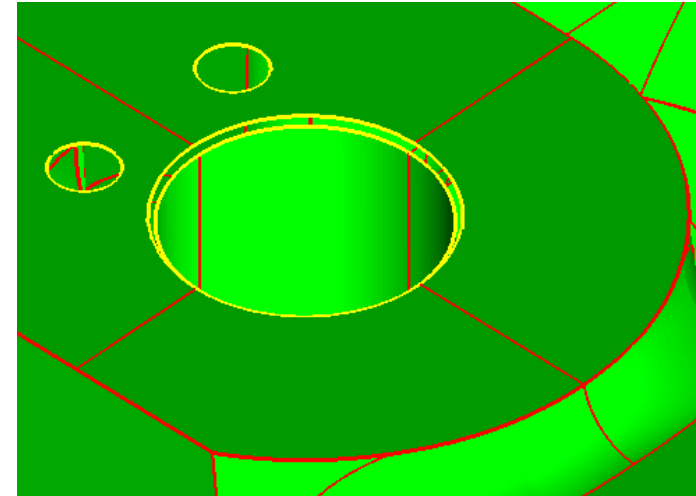


Then use the close holes button to select the curves for half of the hole



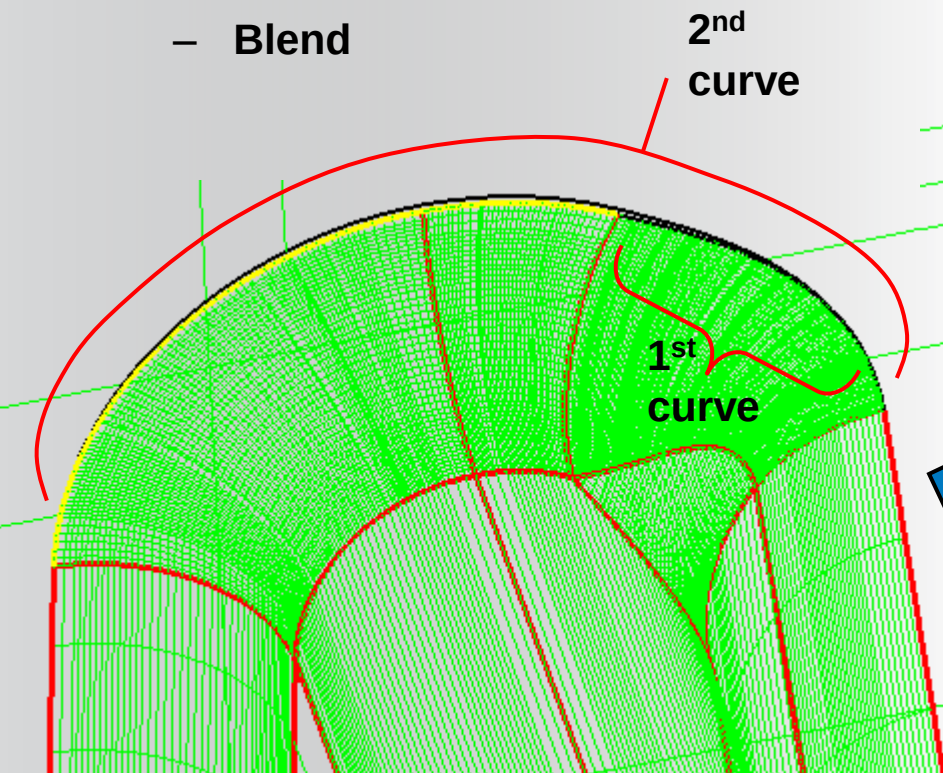
Other Stitch Methods

- Try the other stitch methods at this slot
 - Fill
 - Blend
 - Enforces surface tangency at curves
 - Match
 - Match looks like extend/trim, but it's not the same. Match adjusts surface curvature while extend/trim just extends or trims along the current surface shape

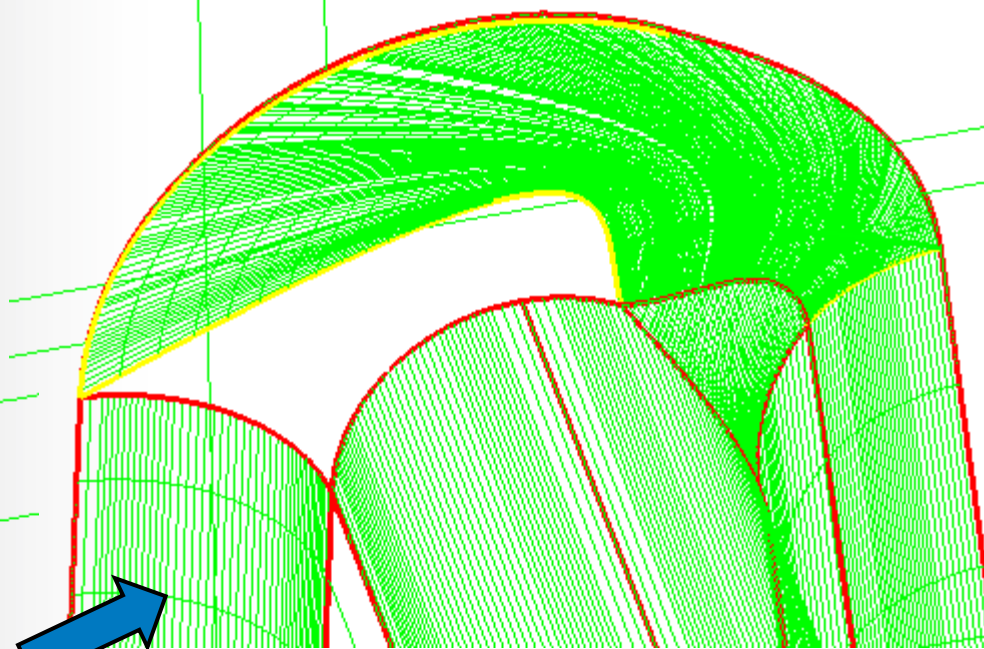


Different Length Curves

- Investigate what happens with all the stitch/match methods when the selected curves have greatly different lengths
 - Match
 - Extend/trim
 - Fill
 - Blend



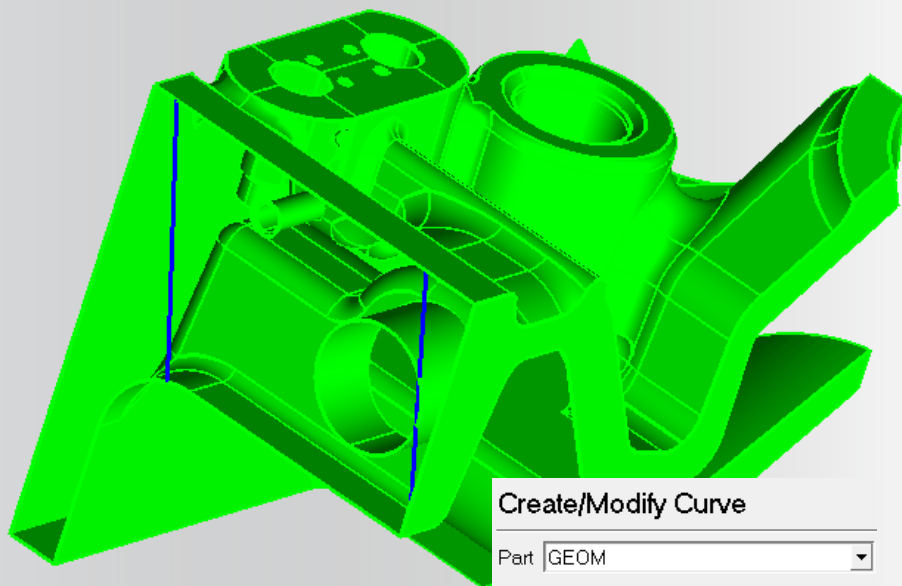
Surfaces shown in wireframe/full



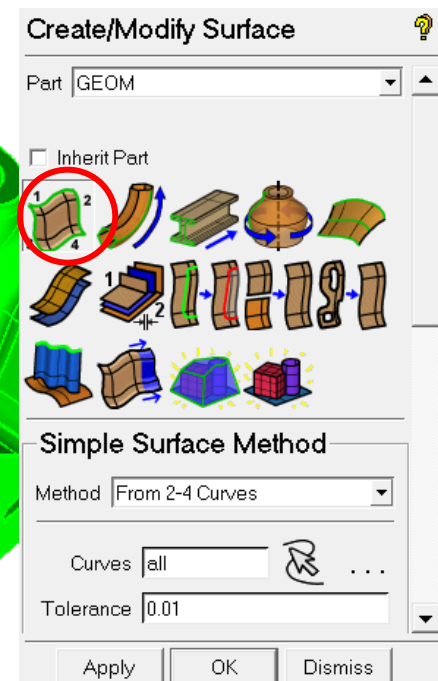
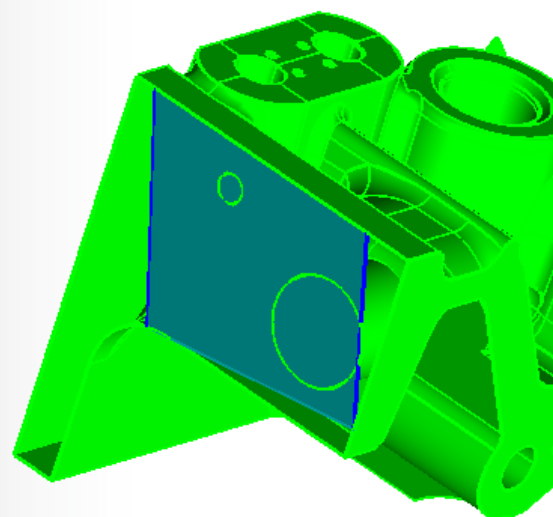
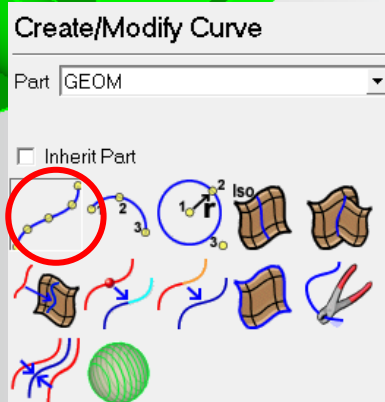
This is the match example without segmenting the curves first. The first surface is stretched so that the full length of the first curve matches up to the full length of the second curve. This shows that curves should have similar length to work well

Capping Surface

- Many times you want to create a capping surface, but you don't have nice, straight curves to make a curve-driven surface as done previously in this tutorial
 - You can create two straight curves on opposite sides in arbitrary locations, and make a fill surface between, then scale the surface larger

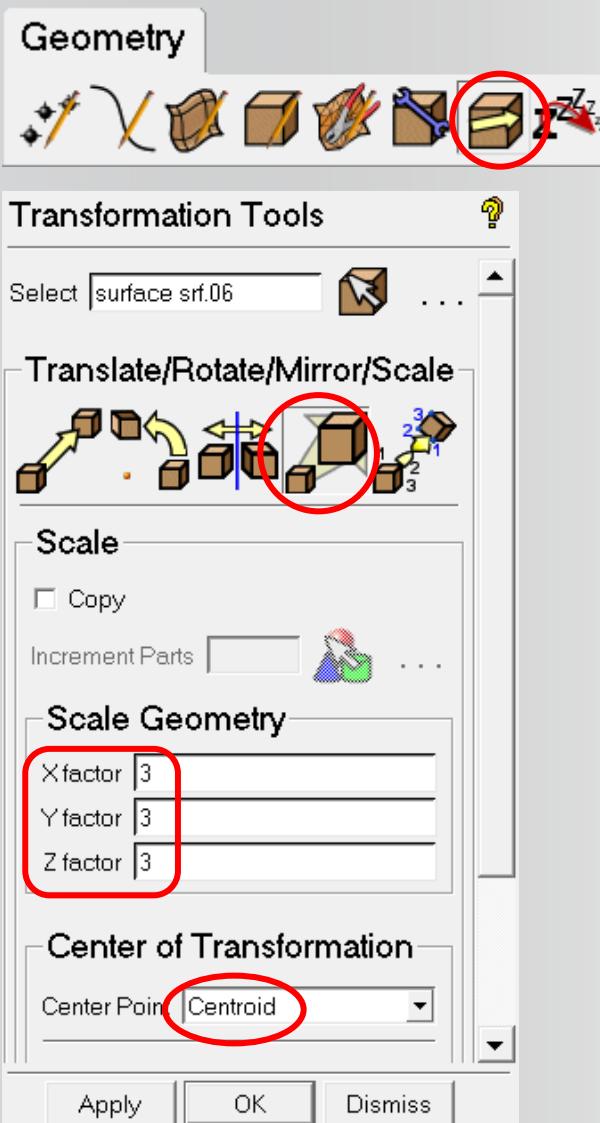


Create 2 curves using the **“from points”** button

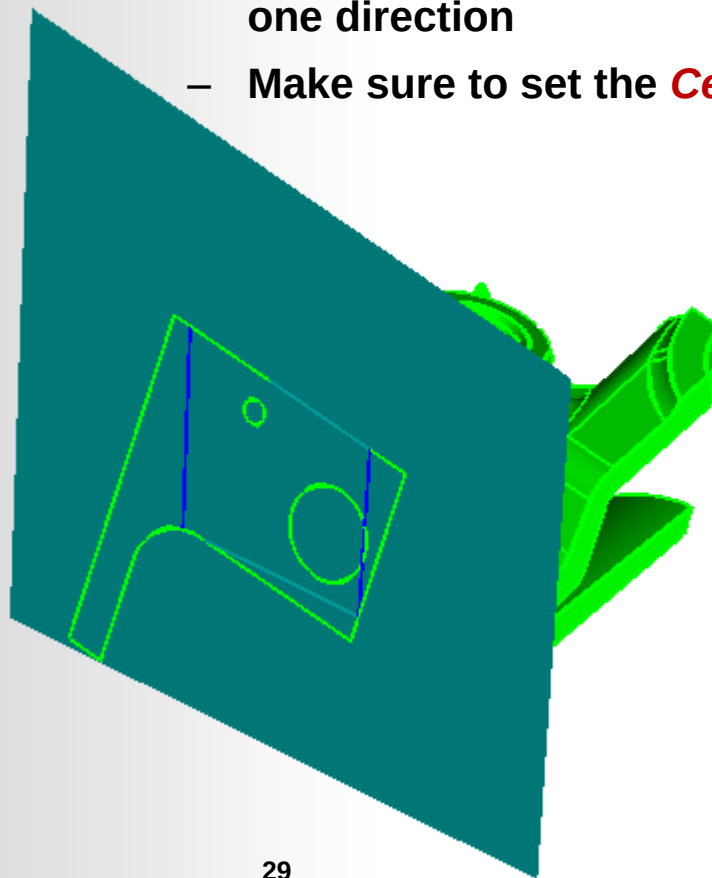


- You can then select the 2 curves using the “simple surface” function
- The surface will connect straight across any gaps if less than 4 curves selected

Capping Surface



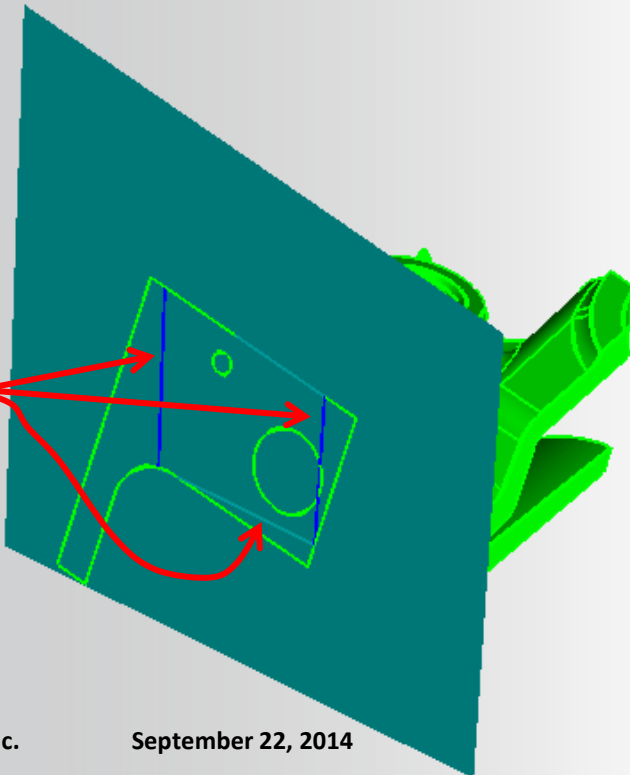
- Scale the surface larger by whatever factor makes it larger than the rest of the geometry for that face
 - Use the same factor for X, Y, and Z, unless you also want to stretch the surface more in one direction
 - Make sure to set the *Center Point* to *Centroid*



Capping Surface

- Delete the original curves you used to make the surface
- Use build diagnostic topology to segment the surfaces
 - Since build topology will segment all surfaces that have curves which span across it or make a loop within it, you will first need to delete the construction curves, otherwise it will segment the surface into more patches
- Finally, delete the unwanted surface segments

Delete these curves first



After building topology, delete the unwanted surface segments

