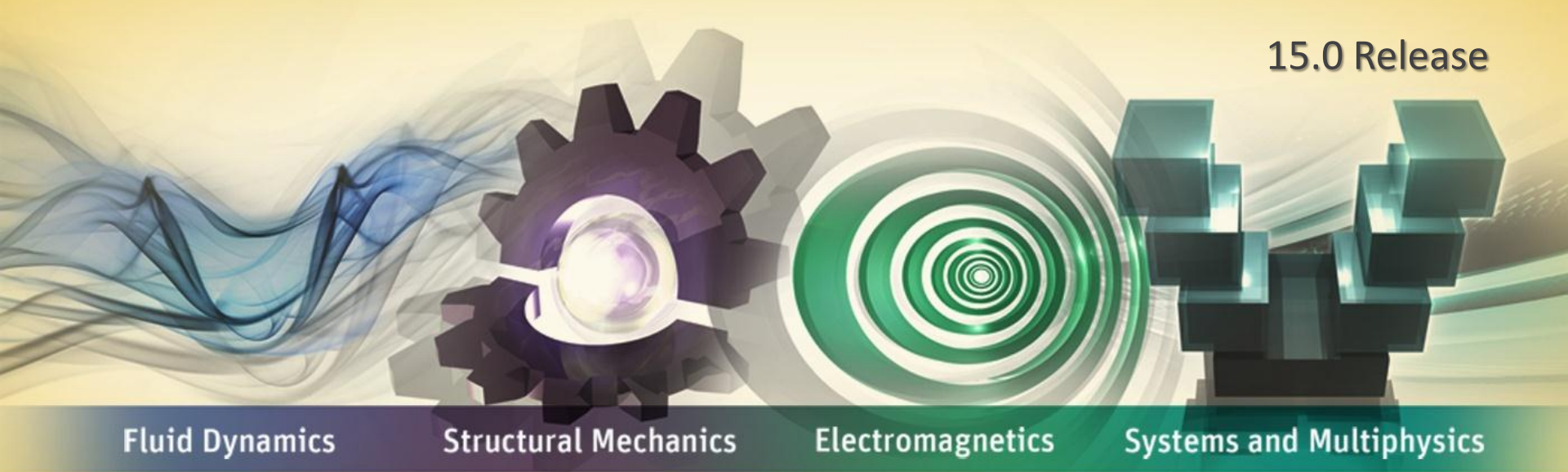


Lecture 5

Prism Meshing

15.0 Release



The banner features four distinct visual elements representing different simulation domains. From left to right: 1. Fluid Dynamics: Represented by blue, wispy, smoke-like or fluid flow patterns. 2. Structural Mechanics: Represented by a dark purple gear with a glowing white and purple center. 3. Electromagnetics: Represented by a series of concentric green circles, suggesting magnetic field lines or wave propagation. 4. Systems and Multiphysics: Represented by a 3D arrangement of teal and black rectangular blocks, some stacked and some floating, suggesting complex system modeling.

Fluid Dynamics

Structural Mechanics

Electromagnetics

Systems and Multiphysics

Introduction to ANSYS

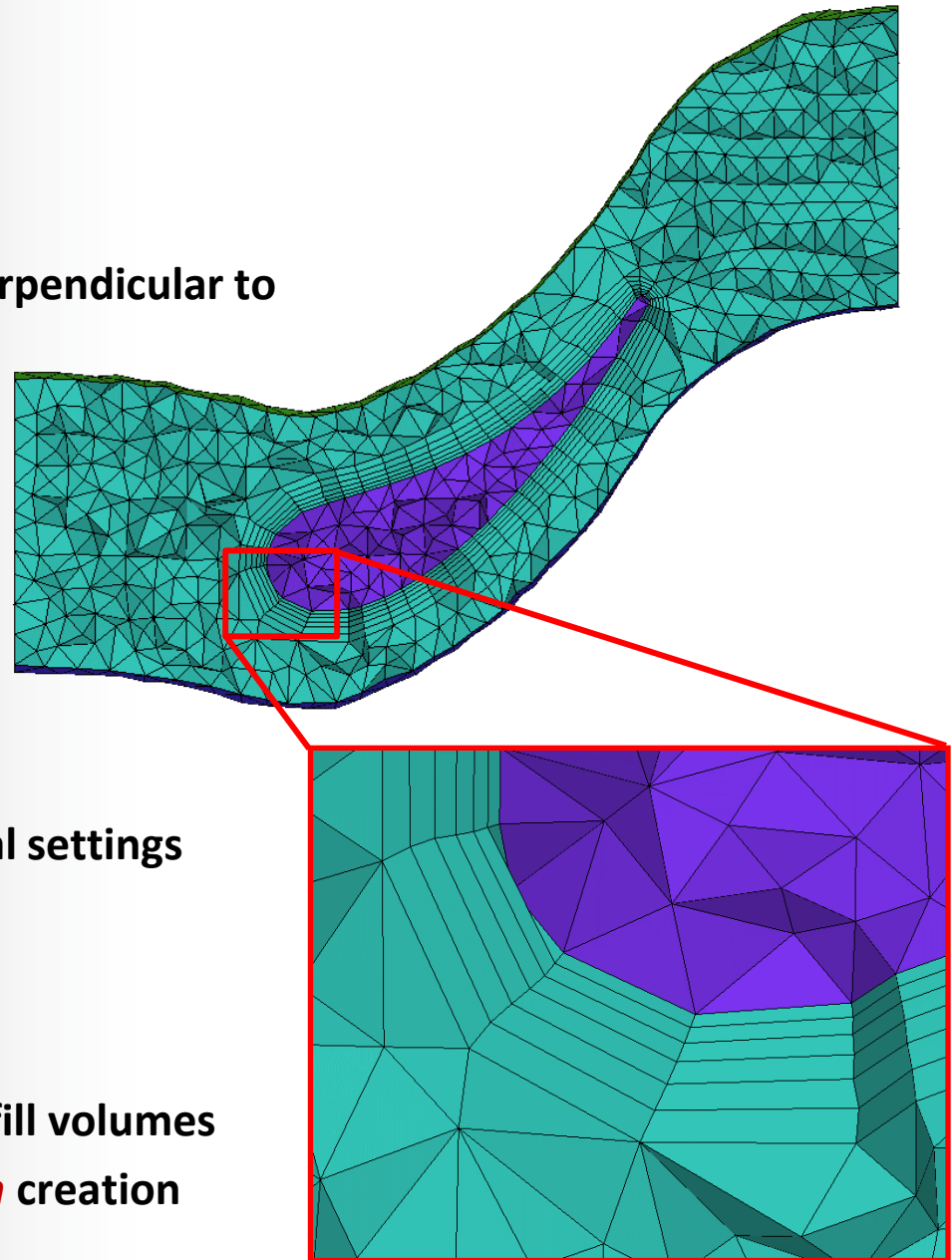
ICEM CFD

Inflation layers

- To better simulate boundary layer effects
- Mesh orthogonal to surface with faces perpendicular to boundary layer flow direction

Procedure

- Set **Global Prism Parameters**
- Select **Parts** to grow layers from
 - Typically wall boundaries and holes
- Set Local Parameters for each part
 - Local overrides global
 - Zero or blank entries will defer to global settings
- Run mesher
 - From existing mesh
 - Extrude into tetra/hexa mesh
 - Extrude from surface tri mesh, then fill volumes
 - Run automatically during **Volume Mesh** creation

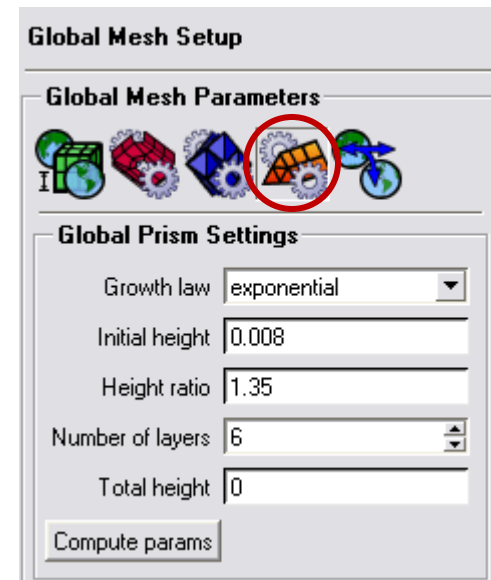


Prism - Global Parameters

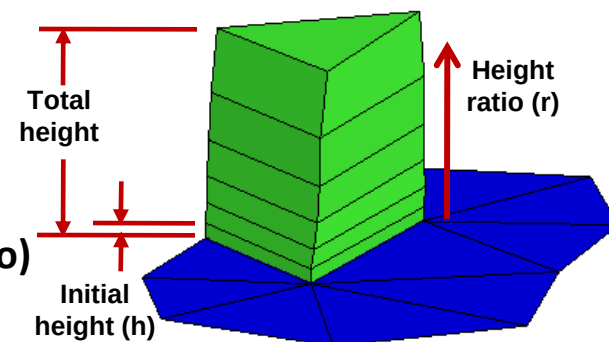
Global Prism Parameters



- **Growth law**
 - **exponential**: $\text{height} = h(r)^{(n-1)}$ [n is layer #]
 - **linear**: $\text{height} = h(1+(n-1)(r-1))$
 - **wb-exponential**: $\text{height} = h * \exp((r-1)(n-1))$
- **Initial height** of first layer – (h) in formulae above
 - Auto calculated if not specified
 - Based on factor of edge length of base triangle/quad
 - Height determined so that top layer volume is slightly less than that of tetra/hex just above it
- **Number of layers** (n)
- **Height ratio** (r) – multiplied by 1st layer to determine 2nd layer
- **Total height** - of all layers
- Usually specify 3 of the above 4 parameters
 - **Compute params** will calculate the remaining parameter (**total height** usually the calculated parameter)
- Or specify only **Height ratio** and **Number of layers** for auto calculation of initial height (initial height and total height zero)
- Individual height/ratio/layers set on surfaces and curves will override these global defaults if set

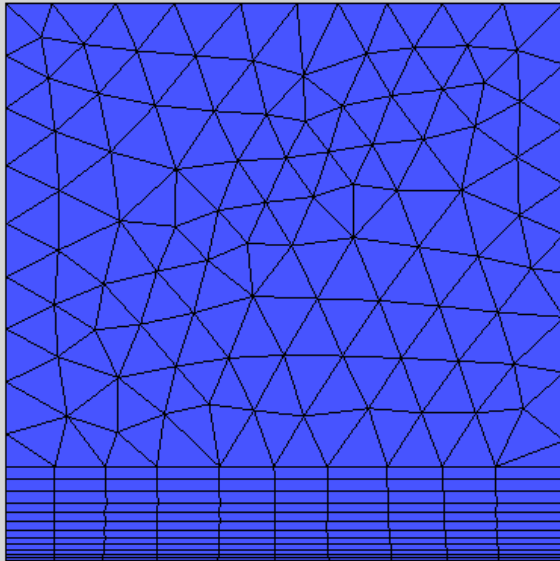


Other global parameters explained later

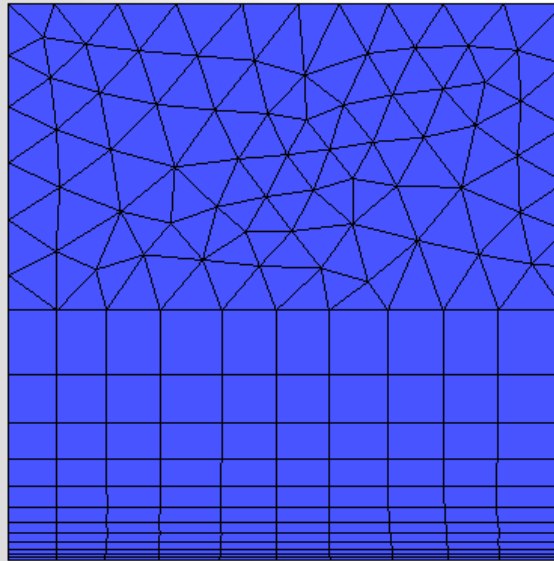


Growth Law Comparison

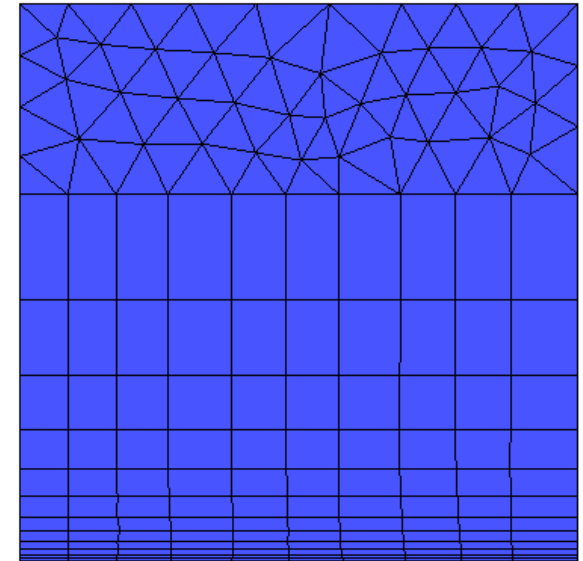
- The growth rate of *Wb-exponential* is slightly greater than *exponential*
- The growth rate of *exponential* is much greater than *linear*



Linear



Exponential



Wb-Exponential

Setting Prism Parameters on Surface Parts

Prism extrusion areas defined by the parts

- **Mesh > Part Mesh Setup**
- Toggle on **Prism** for parts where inflation layers are desired
 - Surface mesh (tri/quad) gets extruded into prisms
- Set **Height, Height Ratio, Num Layers**
 - Will use global defaults if not set or zero



Applying these settings causes these parameters to be applied to each individual surface within each part

If **Apply inflation parameters to curves** is toggled on, they will also be set on each curve within each part

Part Mesh Setup

part ▲	prism	hexa-core	max size	height	height ratio	num layers	tetra size ratio
FAIRING	☐		0	0	0	0	0
FARFIELD	☐		0	0	0	0	0
FUSELAGE	☐		0	0	0	0	0
INLET	☐		0	0	0	0	0
OUTLET	☐		0	0	0	0	0
SYMM	☐		0	0	0	0	0
WING	☐		0	0	0	0	0

☒ Show size params using scale factor
☐ Apply inflation parameters to curves
☐ Remove inflation parameters from curves

Highlighted parts have at least one blank field because not all entities in that part have identical parameters.

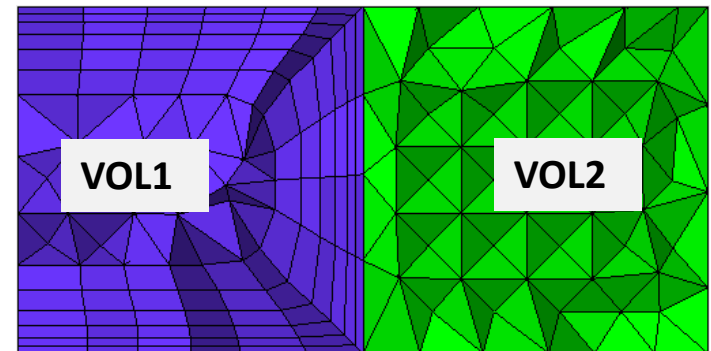
Apply Dismiss

Setting Prism Parameters on Volume Parts

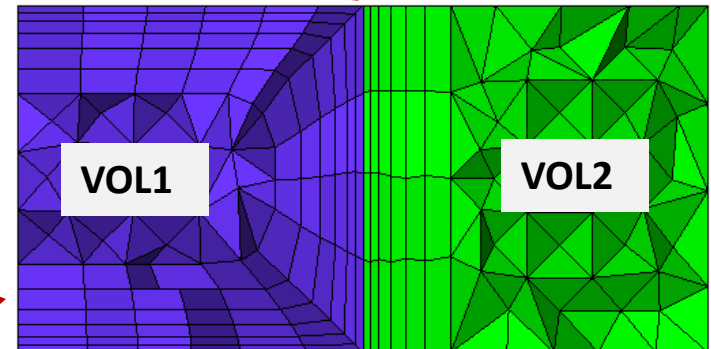
- Normally toggle prism on only for parts that contain surfaces (becomes surface mesh)
- Can also toggle on prism for parts that contain material points (becomes volume mesh)
 - For interior surface mesh, this defines the allowable volumes for extrusion
 - Selecting no volume parts has the same result as selecting all volume parts

Prism Parts Data	
part	prism
GEOM	☐
INTERIOR	☒
VOL1	☒
VOL2	☐
WALLS1	☒
WALLS2	☐

Only one volume part selected



Edge of Interior surface



Prism Parts Data				
part	prism	height	height ratio	num layers
GEOM	☐	0	0	0
INTERIOR	☒	0.01	1.3	6
VOL1	☒			
VOL2	☒			
WALLS1	☒	0.01	1.3	6
WALLS2	☐	0	0	0

☒ Show size params using scale factor

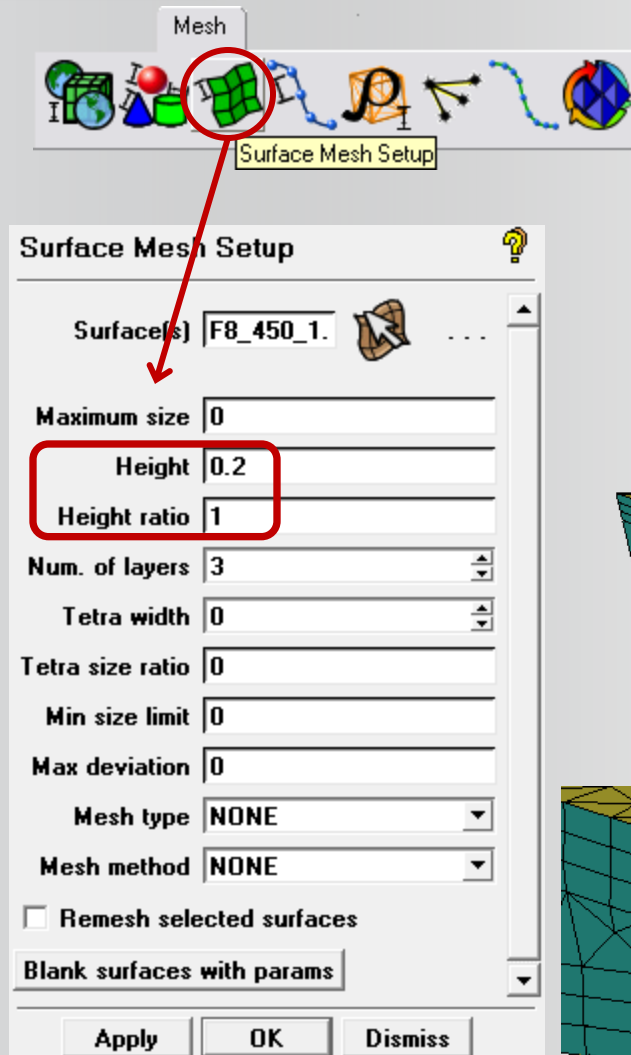
Highlighted parts have at least one blank field because not all entities in that part have identical parameters.

Apply Dismiss

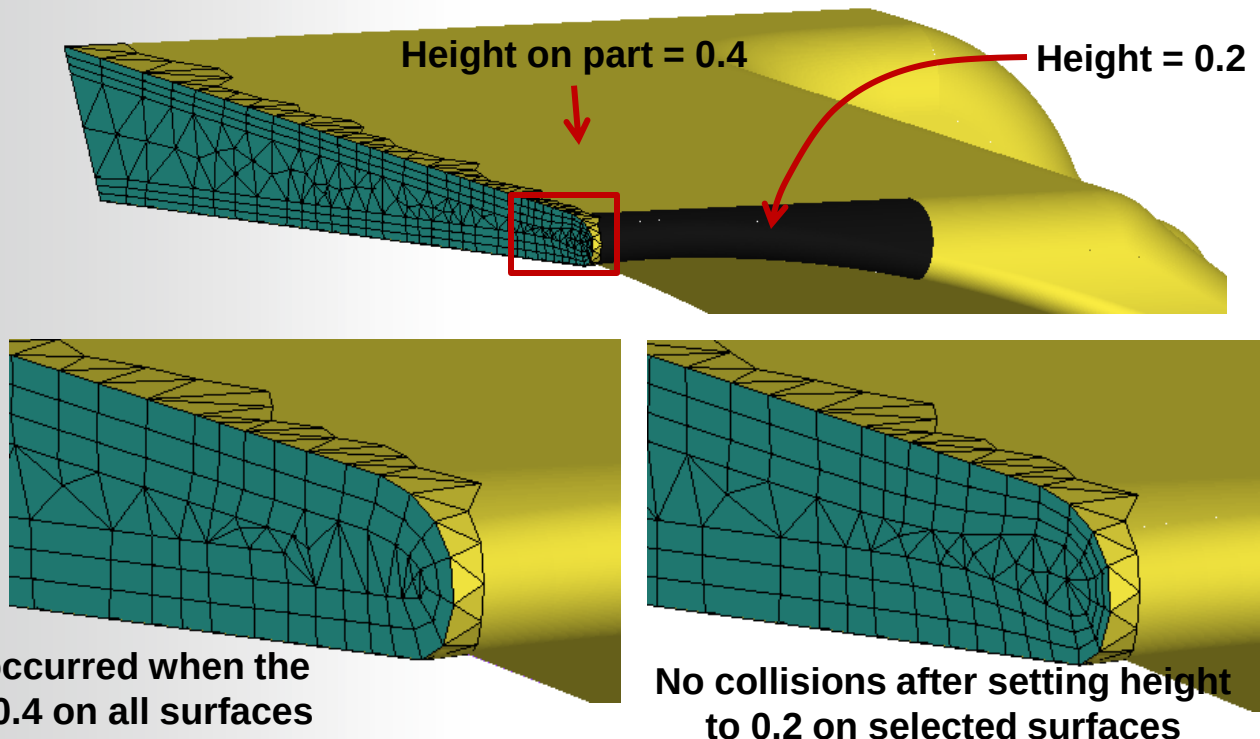
Prism Parts Data	
part	prism
GEOM	☐
INTERIOR	☒
VOL1	☐
VOL2	☐
WALLS1	☒
WALLS2	☐

Both or no volume parts selected

Setting Prism Parameters on Surfaces



- **Mesh > Surface Mesh Setup**
- You can specify different local **height** and **ratio** on any selected surface without moving the surface to a new part (num. layers ignored)
- Usually set **height** and/or **ratio** smaller on specific surfaces to avoid collision

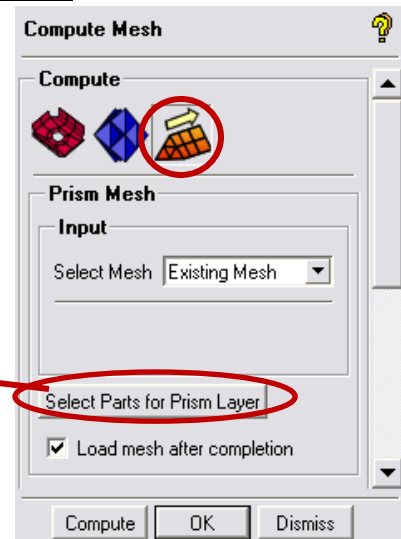
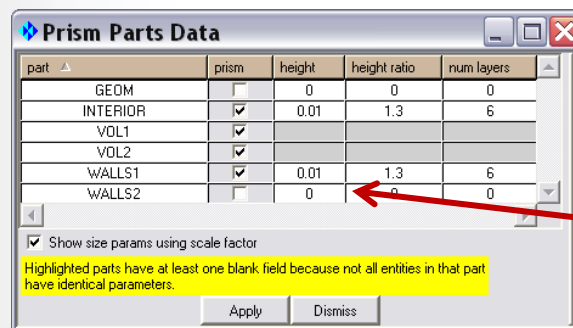


Collisions occurred when the height was 0.4 on all surfaces

No collisions after setting height to 0.2 on selected surfaces

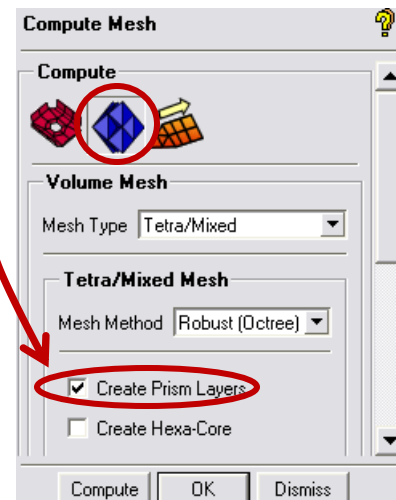
Can run separately

- **Mesh > Compute Mesh > Prism Mesh**
- The **Select Parts for Prism Layer** button pops up the same menu as the **Part Mesh Setup**, except non-prism related columns aren't displayed
- Input
 - **Existing Mesh**
 - **From File** (saves memory by not loading mesh)



Or run automatically linked into volume mesh

- Toggle on Create Prism Layers when tetra meshing
- Not advisable if this is the first mesh for a particular geometry
- Must be confident about setup parameters and sizing
- Running prism separately allows you to smooth and error-check the tri or tetra mesh first.



Input as Surface or Volume Mesh

- Input can be a surface mesh or volume mesh

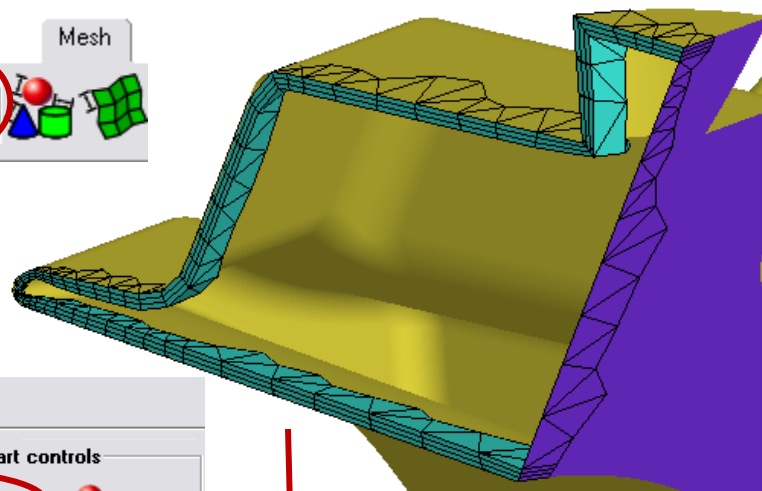
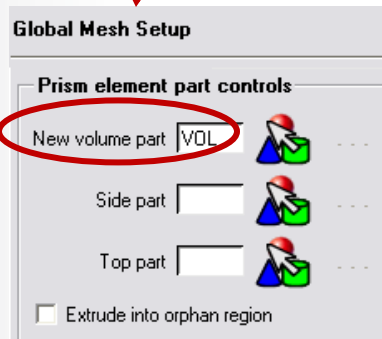
- Surface mesh

- Must be a closed boundary mesh
 - Verify with mesh error checks
- Must specify a **New volume part** in global prism meshing parameters
- Use tetra filling methods after:

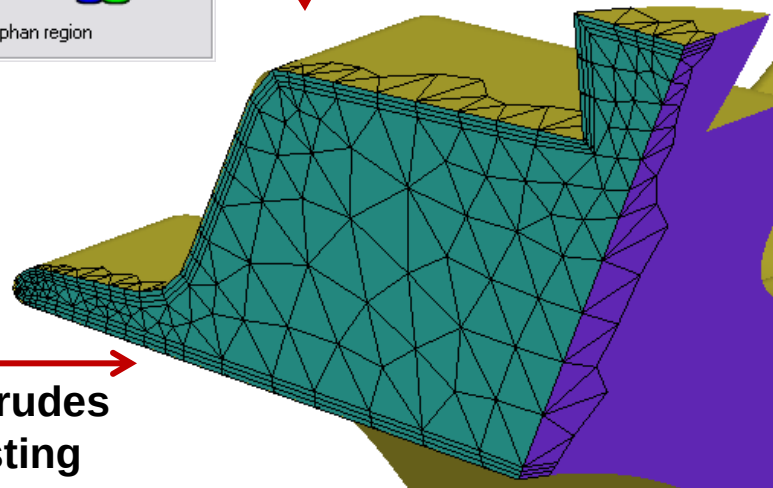
- **Delaunay**
- **Advancing Front**
- **Ansys TGrid**

- Volume mesh

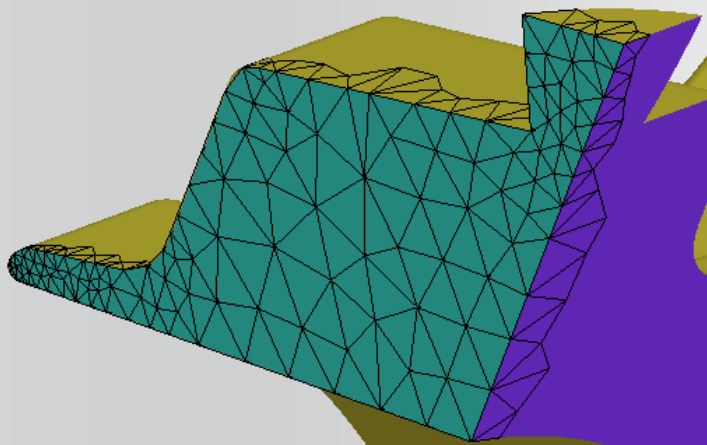
- Moves and reconnects tetras



Delaunay
fill



Prism extrudes
into existing
tetras



Smooth Tetra/Prism Transition

Leave initial height as "0" globally and locally (total height also zero)

- This causes the initial height to float in order to reduce the volume change between the last prism and adjacent tetra.

Global Mesh Setup

Global Mesh Parameters

Global Prism Settings

Growth law: exponential

Initial height: 0

Height ratio: 1.2

Number of layers: 5

Total height: 0

Compute params

☐ Fix marching direction

Min prism quality: 0.000001

Ortho weight: 0.25

Fillet ratio: 0.50

Max prism angle: 180

Max height over base:

Prism height limit factor:

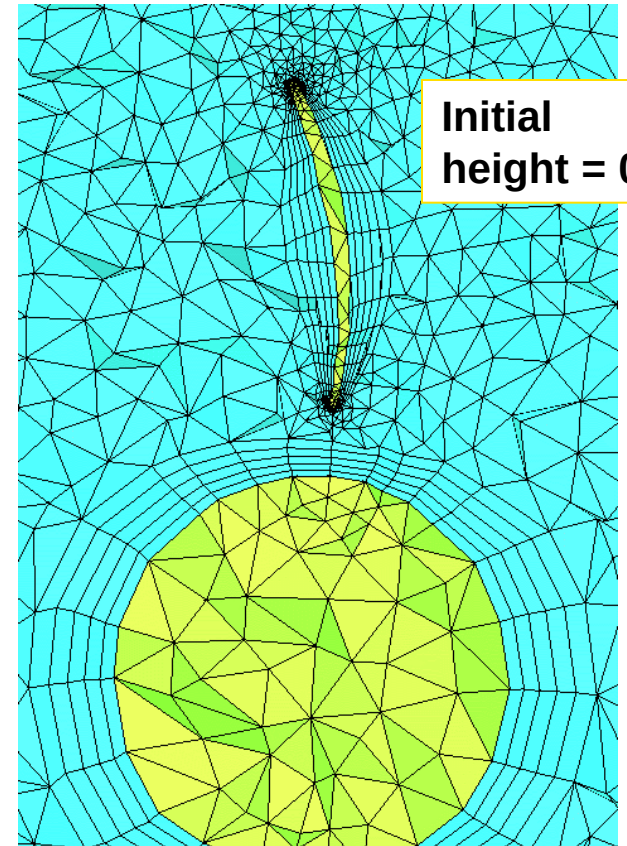
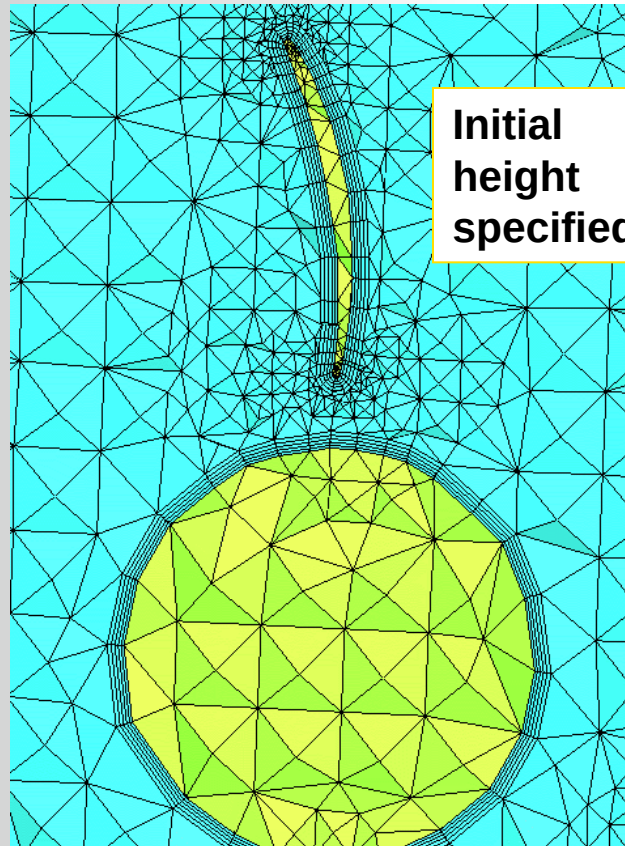
Ratio multiplier:

Apply OK Dismiss

Mesh

Part Mesh Setup

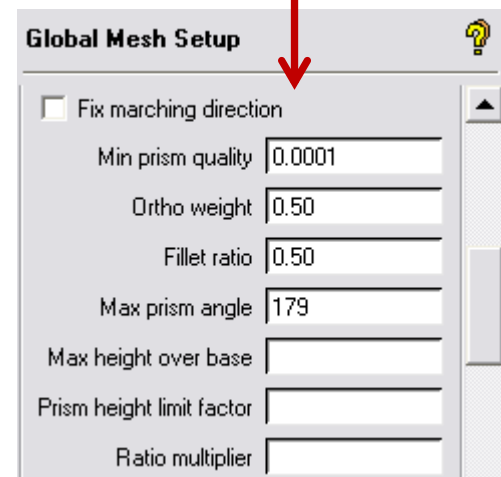
part	prism	hexa-core	max size	height
LEADING_EDGE	☒		0	0
PRESSURE	☒		0	0
SUCTION	☒		0	0
TRAILING_EDGE	☒		0	0



Quality Control Options

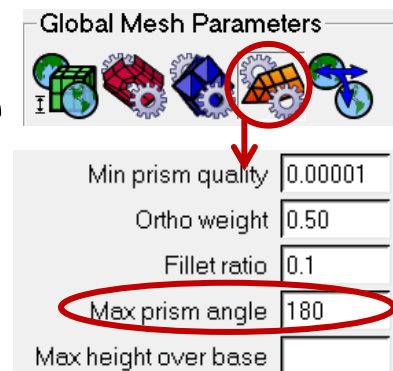
- ***Fix marching direction***
 - Maintains normal from surface
 - Can cause intersections with other mesh
- ***Min prism quality***
 - Either re-smooth directionally or cap/replace with pyramids if quality not met (minimum allowed = 1×10^{-6})
- ***Ortho weight***
 - Weighting factor for node movement from 0 - improving triangle quality, to 1 - improving prism orthogonality
- ***Fillet ratio***
- ***Max prism angle***
- ***Max height over base***
- ***Prism height limit factor***
- ***Ratio multiplier (m)***
 - For varying exponential growth:

$$\text{height} = h(r)^{(n-1)} (m)^{(n-1)}$$

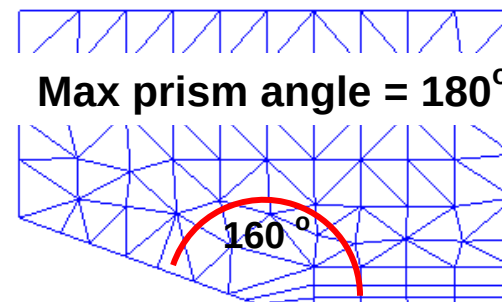
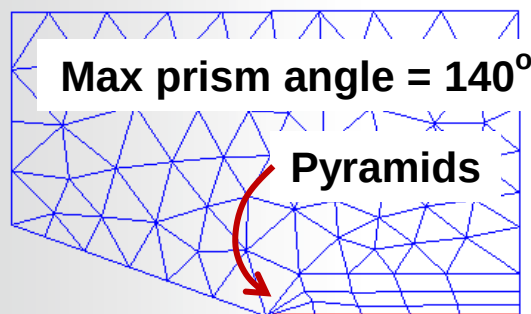
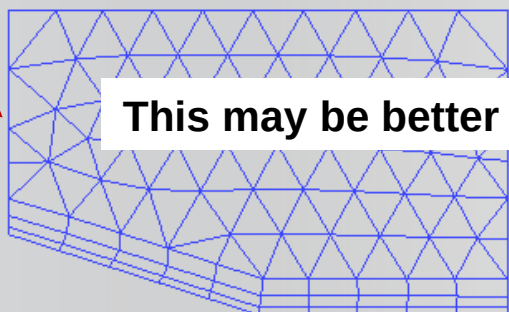


See next slides

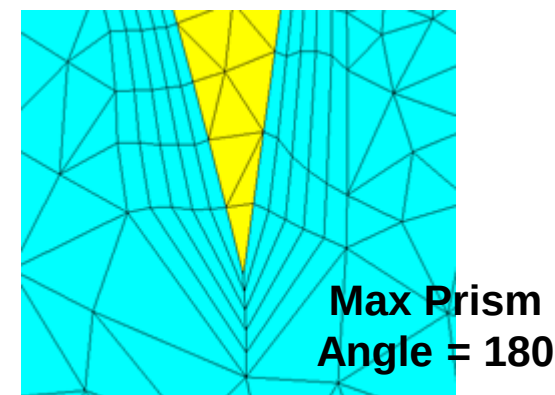
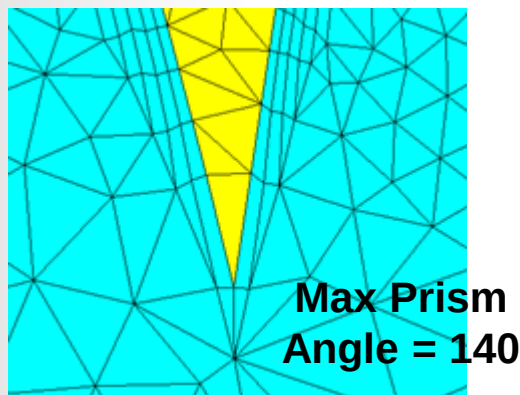
Prism Options – Max Prism Angle



- If the **Max Prism Angle** is not met within a given prism, the prism layers will end and be capped off with pyramids in those locations
- Allowable range is 135° to 180°
- Only higher quality prisms are allowed to form similar to using a high **min prism quality**. However, the pyramids on the sides are usually of lower quality
- Running prism along adjacent surfaces until it can end at a smaller angle will avoid pyramids, but total element count will be greater

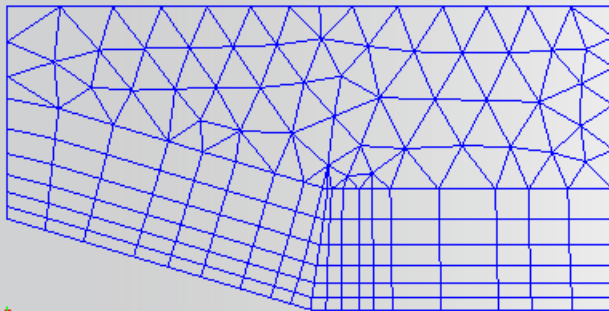
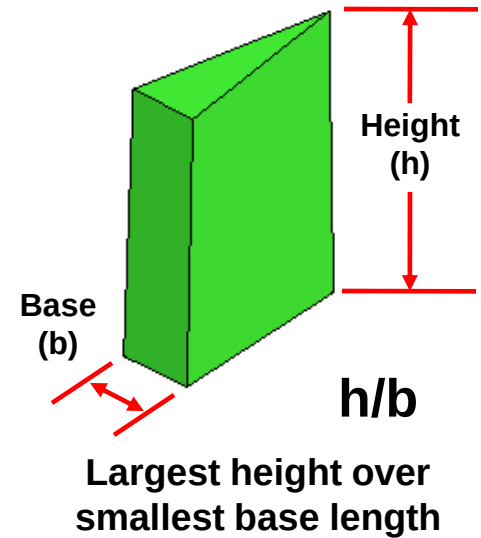


- A high (up to 180°) **Max Prism Angle** keeps the prism layers connected around tight bends.
 - Set this to 180 to prevent pyramids wherever possible

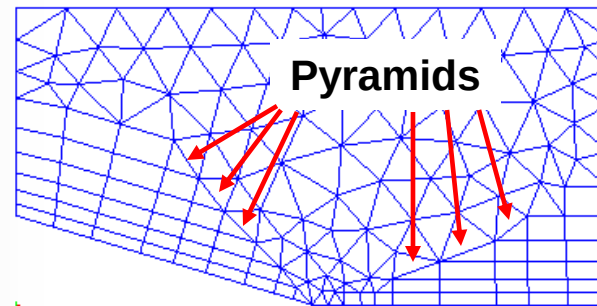


Prism Options – Max Height Over Base

- Restricts prism aspect ratio
- Prism layers stop growing in regions where prism aspect ratio would exceed specified value
 - Number of prism layers would not be preserved locally
- Mesh is made conformal with pyramids at prism boundaries
- Acceptable values vary widely (typically 0.5 – 8)



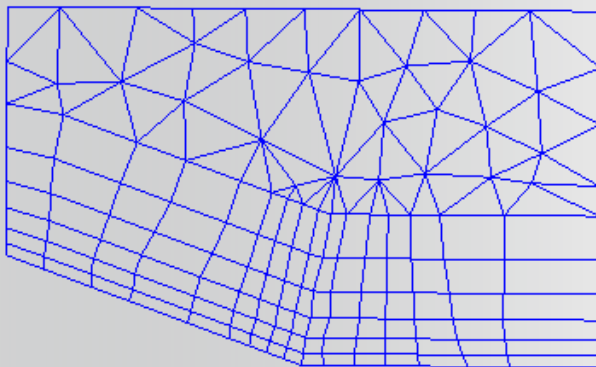
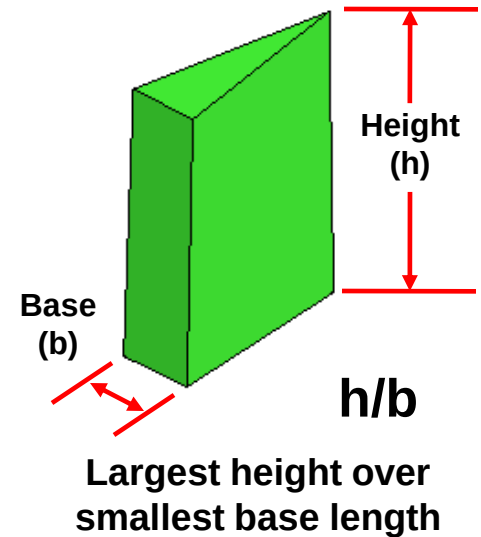
Max Height Over Base not set



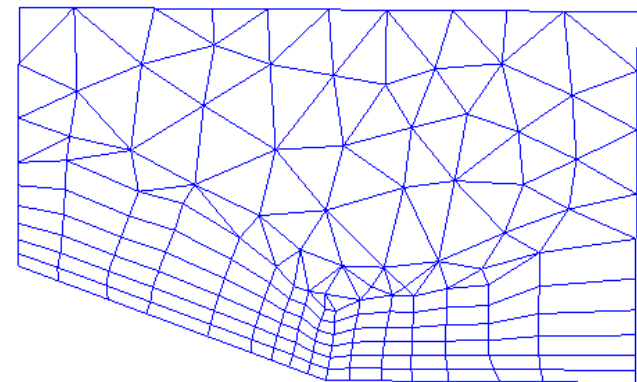
Max Height Over Base = 1.0

Prism Options – Prism Height Limit Factor

- Restricts prism aspect ratio
 - Prism height will not expand once this factor is met
- Uses the same height over base factor as the previous metric except prism layers are not capped off with pyramids
- Preserves the specified number of prism layers
- “Pulls in” the prism layers to reduce heights
- Will fail if sizes of adjacent elements differ by more than a factor of 2
- Acceptable values vary widely (typically 0.5 – 8)



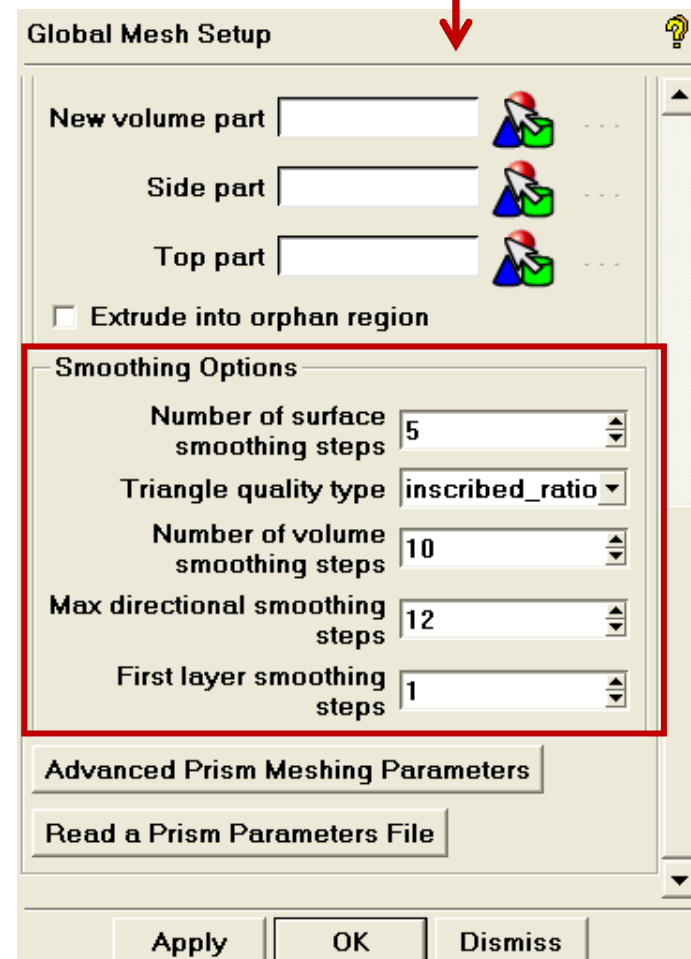
Limit factor not set



Limit factor = 0.5

Prism Options - Smoothing

- Smooths inflation layers during prism creation
 - **Number of surface smoothing steps**
 - Prepares tri's for best prism quality
 - Set surface/volume steps to 0 if only extruding one layer or if tri/tetra mesh is already smoothed
 - **Triangle quality type**
 - Laplace typically best for eventual prism quality
 - Other types may be better when marching directions condense at inside corners
 - **Max directional smoothing steps**
 - These are the most important smoothing iterations done during prism generation
 - Redefines extrusion direction based on initial prism quality
 - internally calculated for each layer
 - **First layer smoothing steps**
 - Used for the first layer only when “**Fix marching direction**” is on



Smoothing a Tetra/Prism Mesh Afterward

After generating prisms: **Edit Mesh > Smooth Mesh Globally**

- Prisms are smoothed during prism generation
- The tetras and tri's adjacent to the last prism layer will be worse

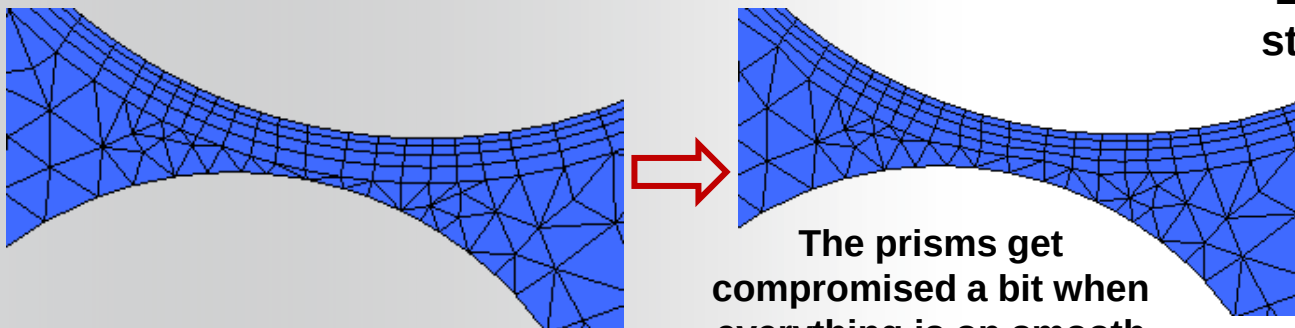
1. First smooth only the tetras and tris (**Up to value** ≈ 0.3)

- Set **PENTA_6** and **PYRA_5** to **Freeze**
- Don't want to modify the prism layers at this point

2. Once tetra and tri elements are as smooth as possible, smooth all elements

- Set **PENTA_6** and **PYRA_5** back to **Smooth**
- Decrease the **Up to value** (≈ 0.1) so as not to distort prism elements too much

- 0.05 quality target minimum if pyramids exist, 0.2 if none



The prisms get compromised a bit when everything is on smooth



Smooth Elements Globally

Quality

Smoothing iterations: 5

Up to value: 0.2

Criterion: Quality

Smooth Mesh Type

	Smooth	Freeze	Float
TETRA_4	☒	☐	☐
TRI_3	☒	☐	☐
PENTA_6	☐	☒	☐
QUAD_4	☒	☐	☐
PYRA_5	☐	☒	☐

1st
step

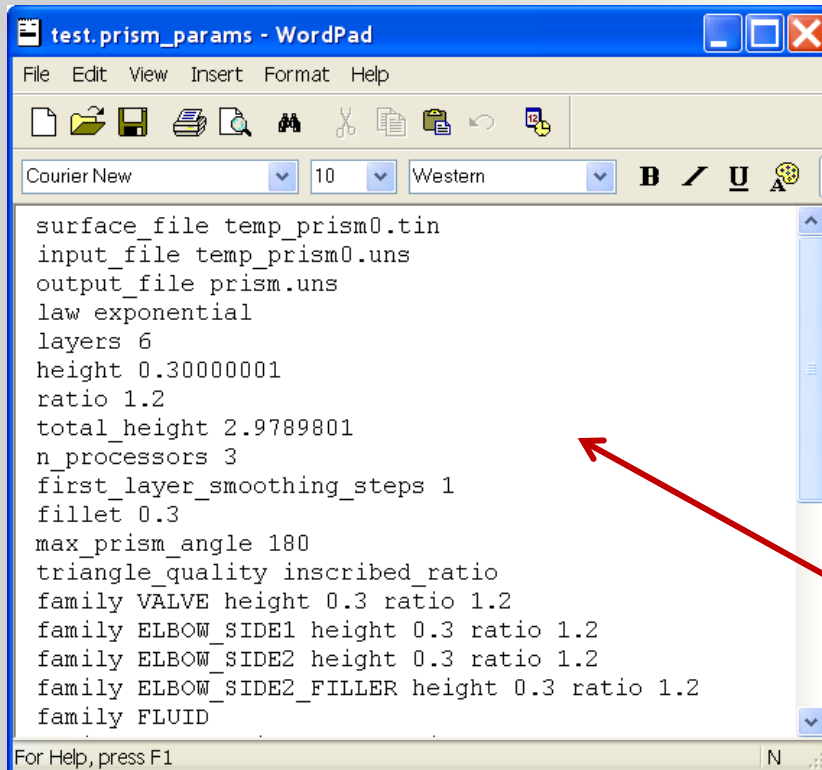
Smooth Mesh Type

	Smooth	Freeze	Float
TETRA_4	☒	☐	☐
TRI_3	☒	☐	☐
PENTA_6	☒	☐	☐
QUAD_4	☒	☐	☐
PYRA_5	☒	☐	☐

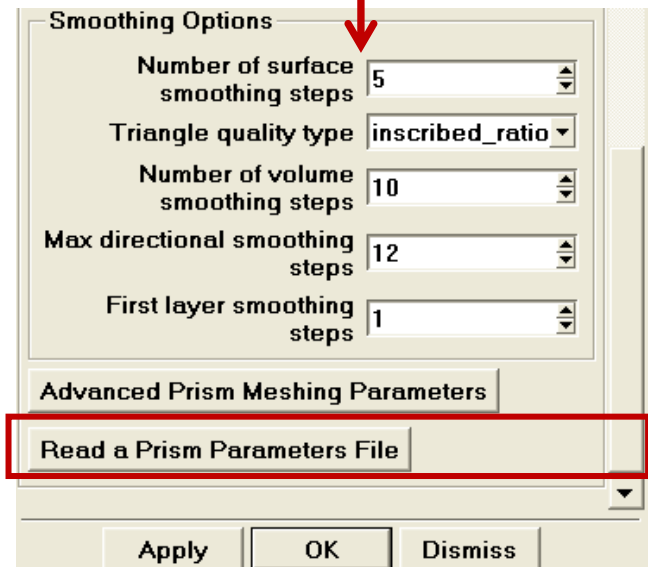
2nd
step

Prism Parameters File

- **Read a Prism Parameters File**
 - To set all prism values from a prism settings file (*.prism_params)
 - Written to the working directory every time prism is run



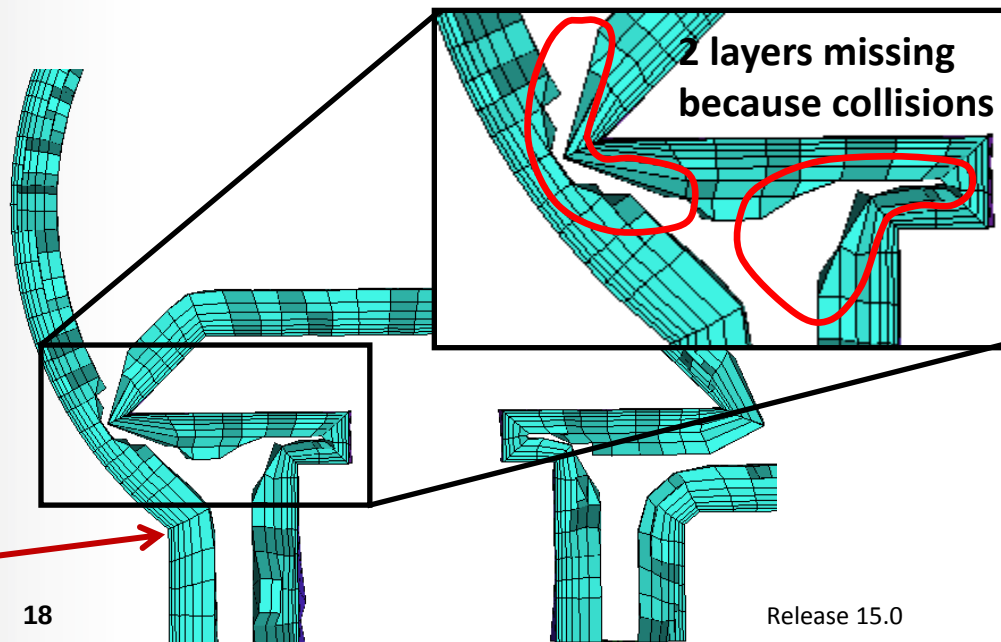
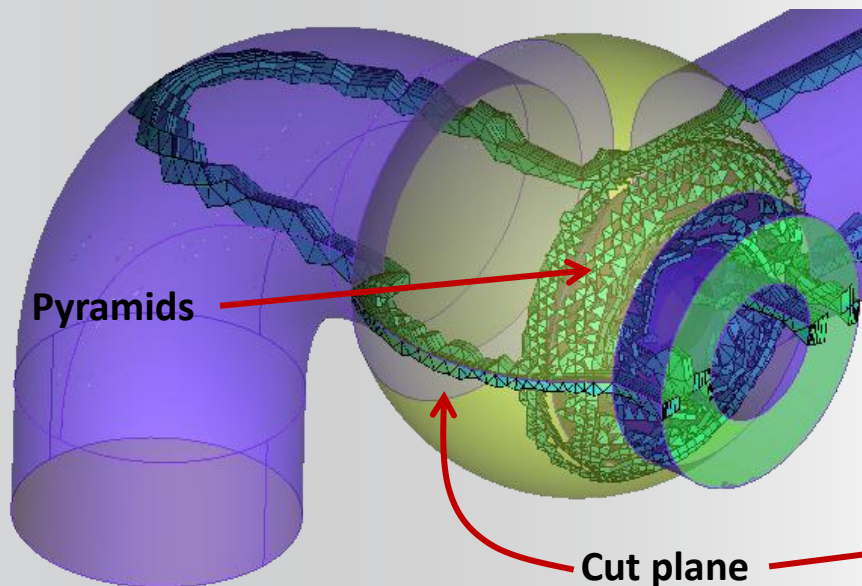
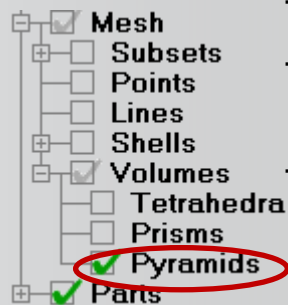
```
surface_file temp_prism0.tin
input_file temp_prism0.uns
output_file prism.uns
law exponential
layers 6
height 0.30000001
ratio 1.2
total_height 2.9789801
n_processors 3
first_layer_smoothing_steps 1
fillet 0.3
max_prism_angle 180
triangle_quality inscribed_ratio
family VALVE height 0.3 ratio 1.2
family ELBOW_SIDE1 height 0.3 ratio 1.2
family ELBOW_SIDE2 height 0.3 ratio 1.2
family ELBOW_SIDE2_FILLER height 0.3 ratio 1.2
family FLUID
```



Typical prism parameters file

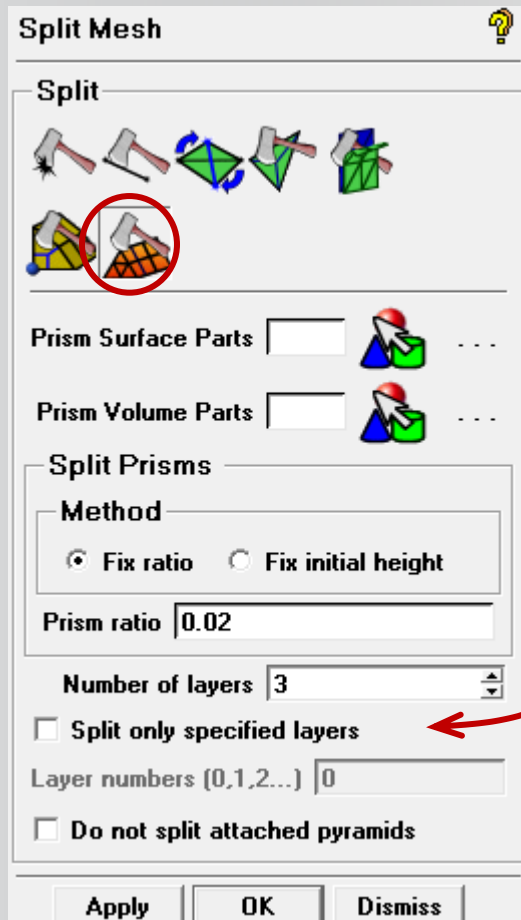
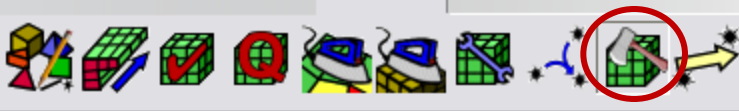
Checking for Problems

- Pyramids form where prism has problems
 - Wherever prism layers stop forming, the sides are capped off with pyramids
 - Collisions are the most common cause, and can make prism.exe crash if severe enough. Need to locally reduce heights, ratios, or num layers.
 - Other common causes are the min prism quality or max prism angle is violated, or a geometric formation cannot have continuous prisms (scissors junction), or other problems.
- The first thing to do after the prism process is turn on only pyramids
- Inspect for what is wrong. View a cut plane through these regions

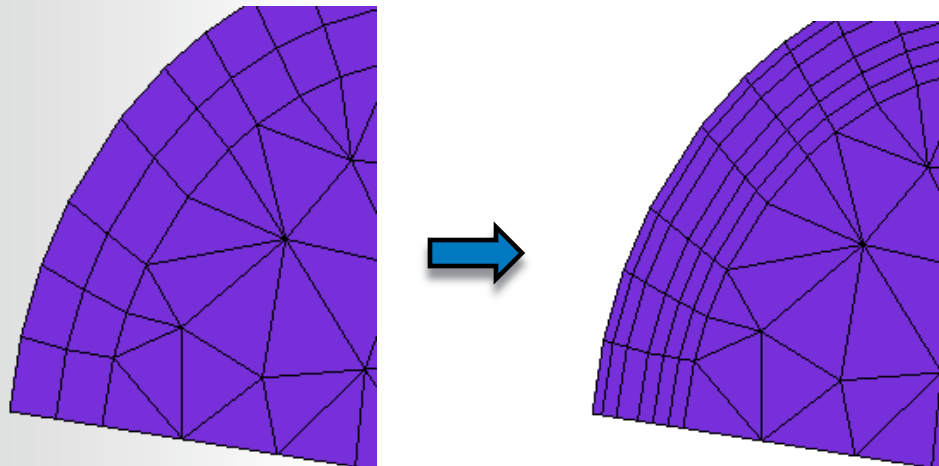


Splitting Prism Layers

Edit Mesh



- If many prism layers are desired, it is faster, but less robust – to create a few “fat” layers and then split them with mesh editing
- **Edit Mesh > Split Mesh > Split Prisms**
 - **Fix ratio:** The layer is split such that its resulting layers employ the given growth ratio (height is free variable to adjust)
 - **Fix initial height:** The layer is split such that its first sub-layer is of the given height (ratio is free variable)
- Specify the number of layers to result from each existing layer
- Can split specified or all existing layers



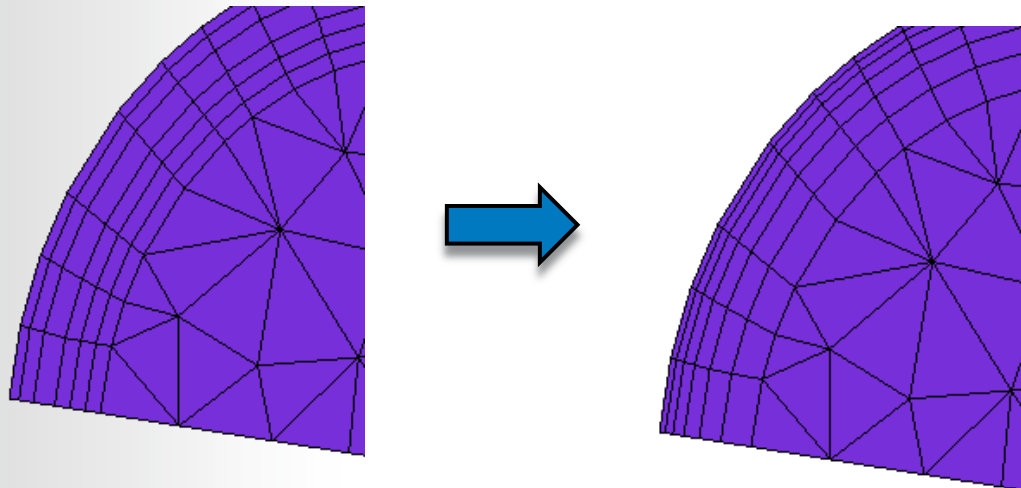
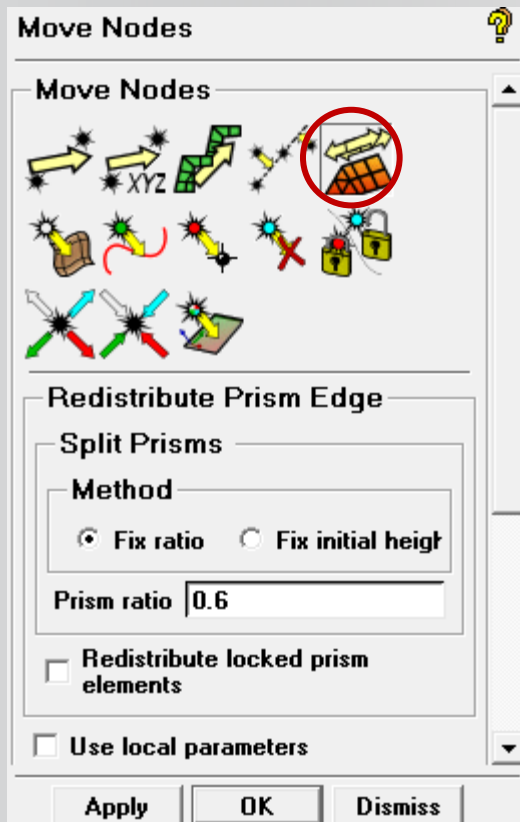
Redistributing Prism Layers

Edit Mesh



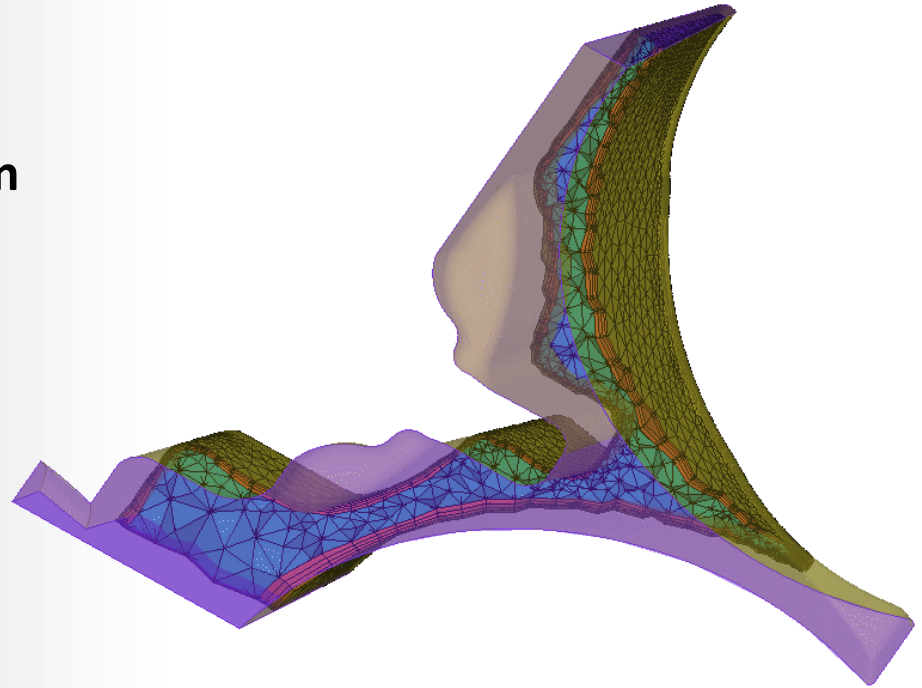
Redistribute prism layers after splitting

- **Edit Mesh > Move Nodes > Redistribute Prism Edge**
 - **Fix ratio:** The initial height and subsequent layer heights will be adjusted to achieve this growth ratio
 - **Fix initial height:** The growth ratio is the variable that will be adjusted to achieve this initial height
 - The total prism thickness remains fixed and layers are adjusted within this thickness



• Workshop 5.1 – Waterjacket Section

- Setting prism parameters
- Prism into tetra mesh
- Inspecting pyramids
- Setting local heights
- Remesh to get rid of pyramids
- Redistribute prisms



• Workshop 5.2 – Wingbody

- Prism from surface mesh
- Initial height as zero
- Create a density region
- Delaunay fill
- Smoothing
- Hexa core fill

