

Introduction to the Finite Element Method (FEM) – II

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06/2021

Univerza v Ljubljani



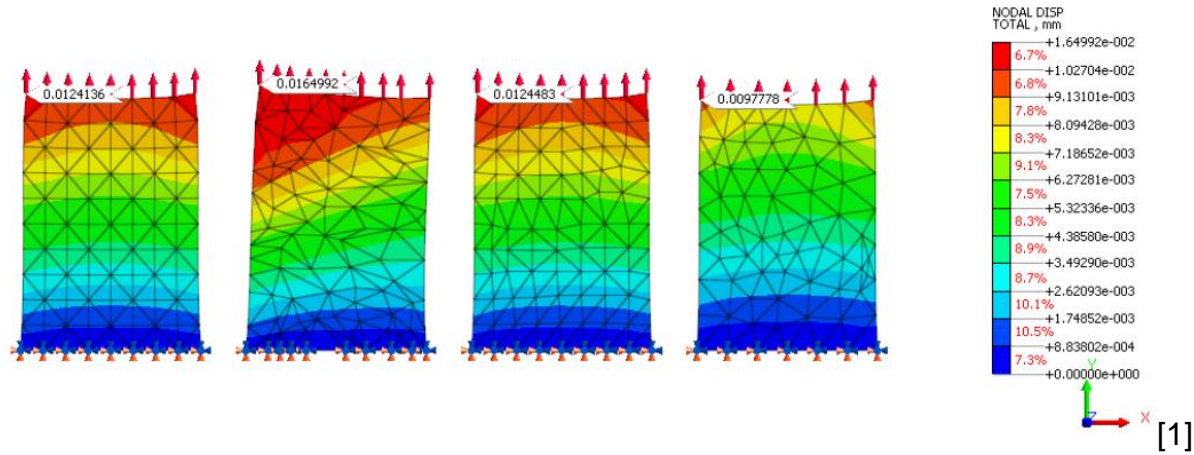
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Why is meshing important

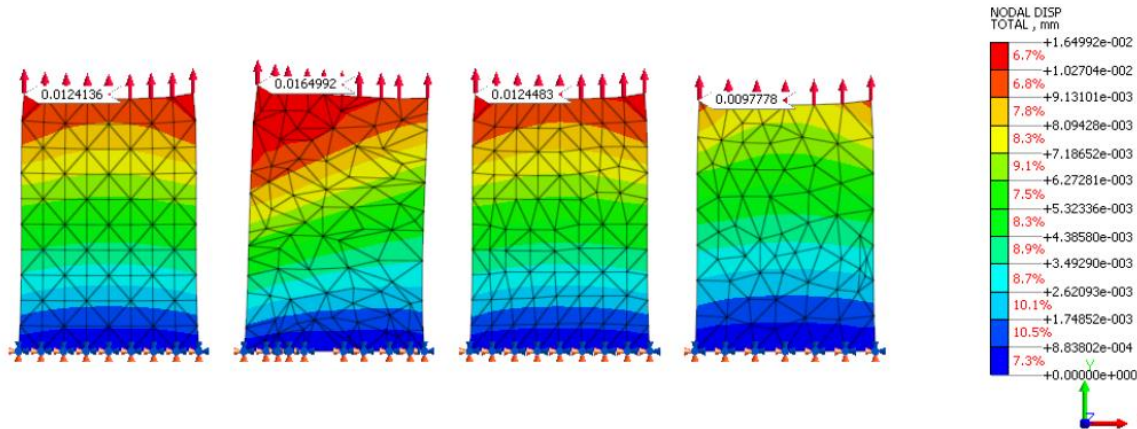
displacement



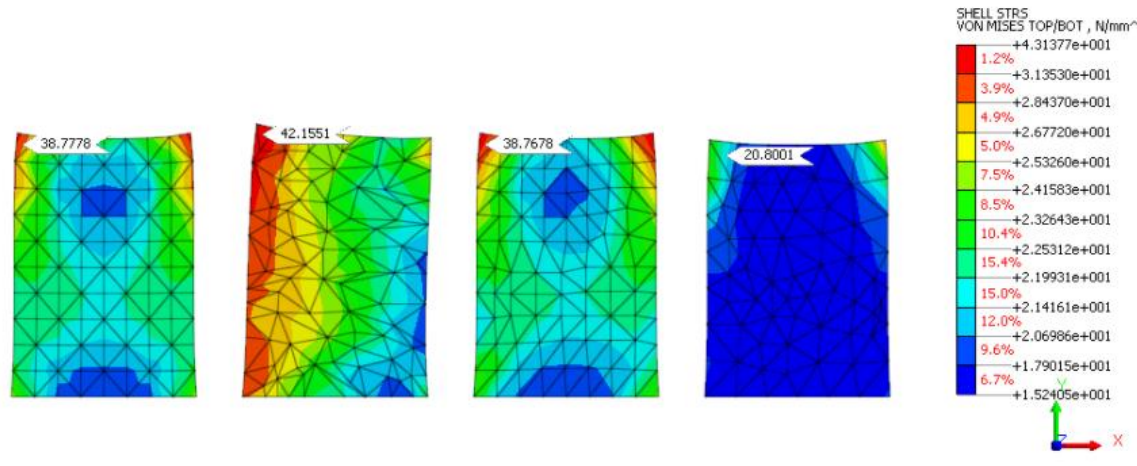
[1] 7 wrong beliefs about meshing that you may have, Available at: <https://feaforall.com/7-wrong-meshing-beliefs-may/>

Why is meshing important

displacement



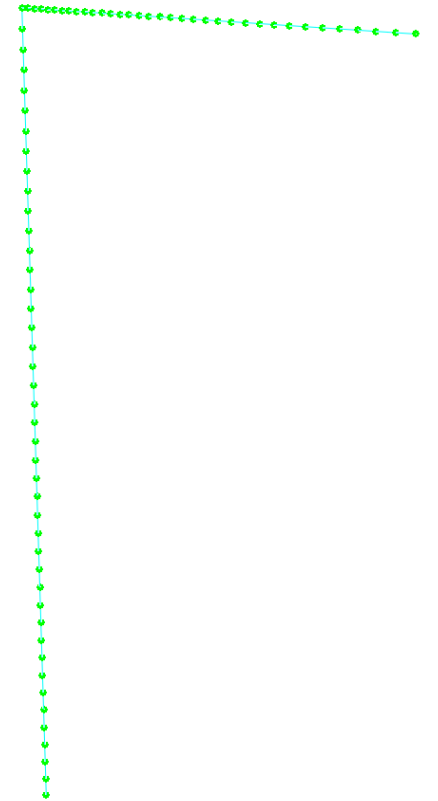
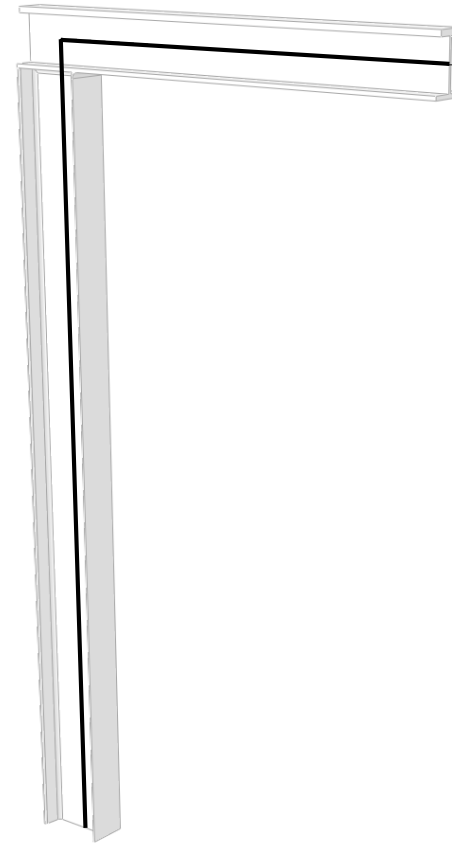
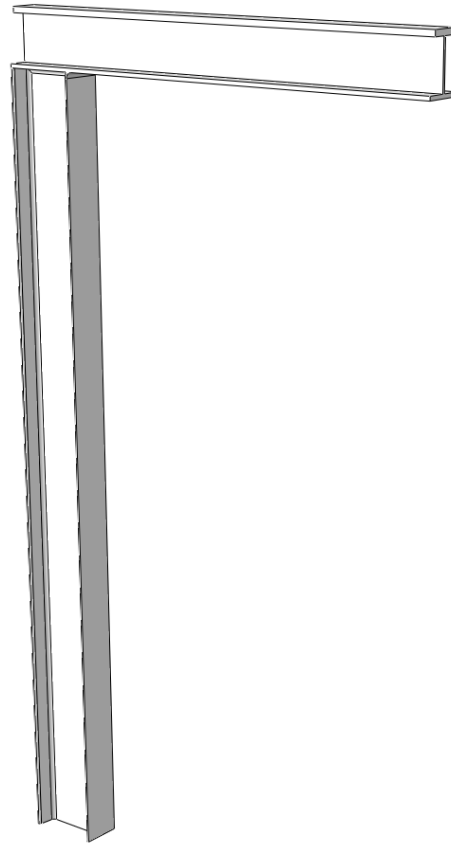
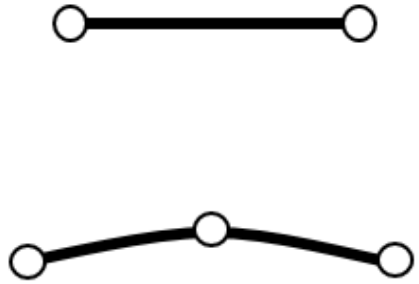
Von Mises stress



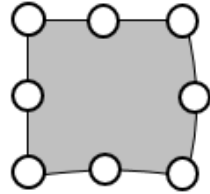
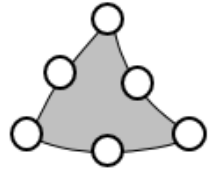
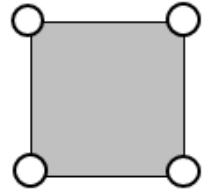
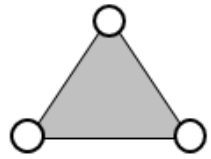
[1]

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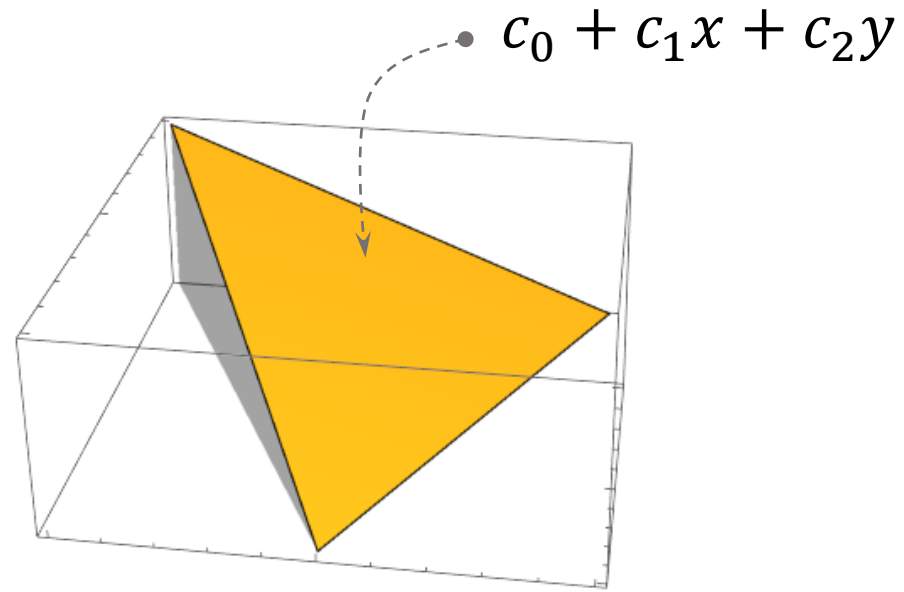
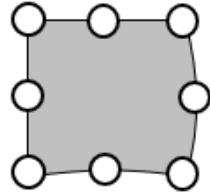
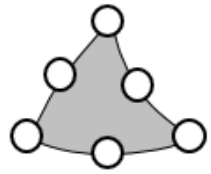
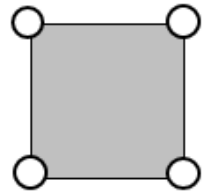
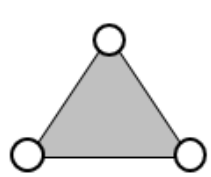
1D Elements/Meshing



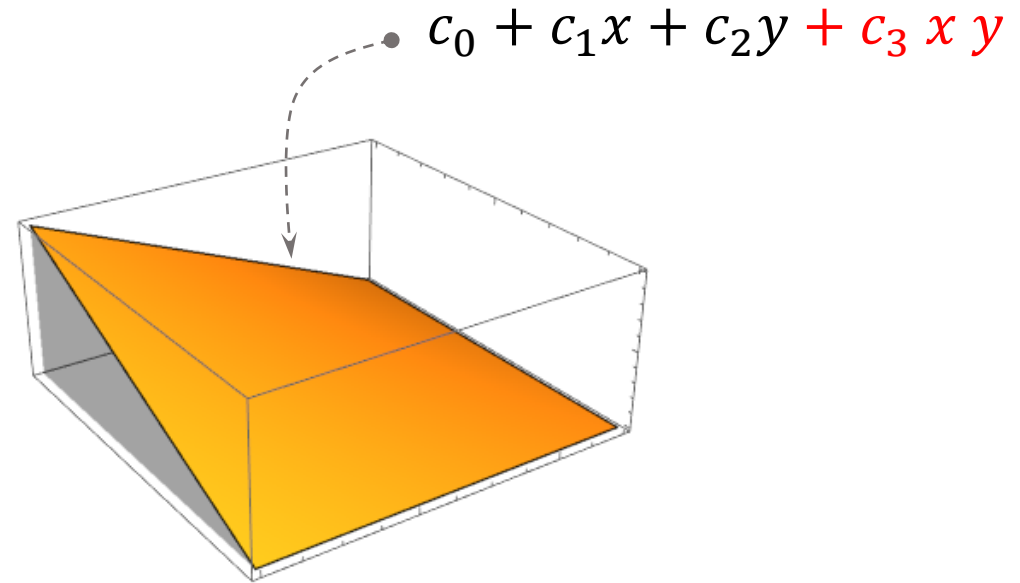
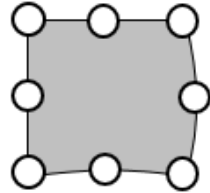
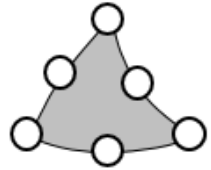
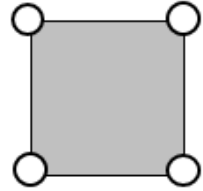
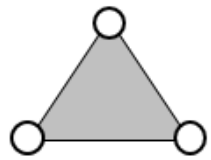
2D Elements



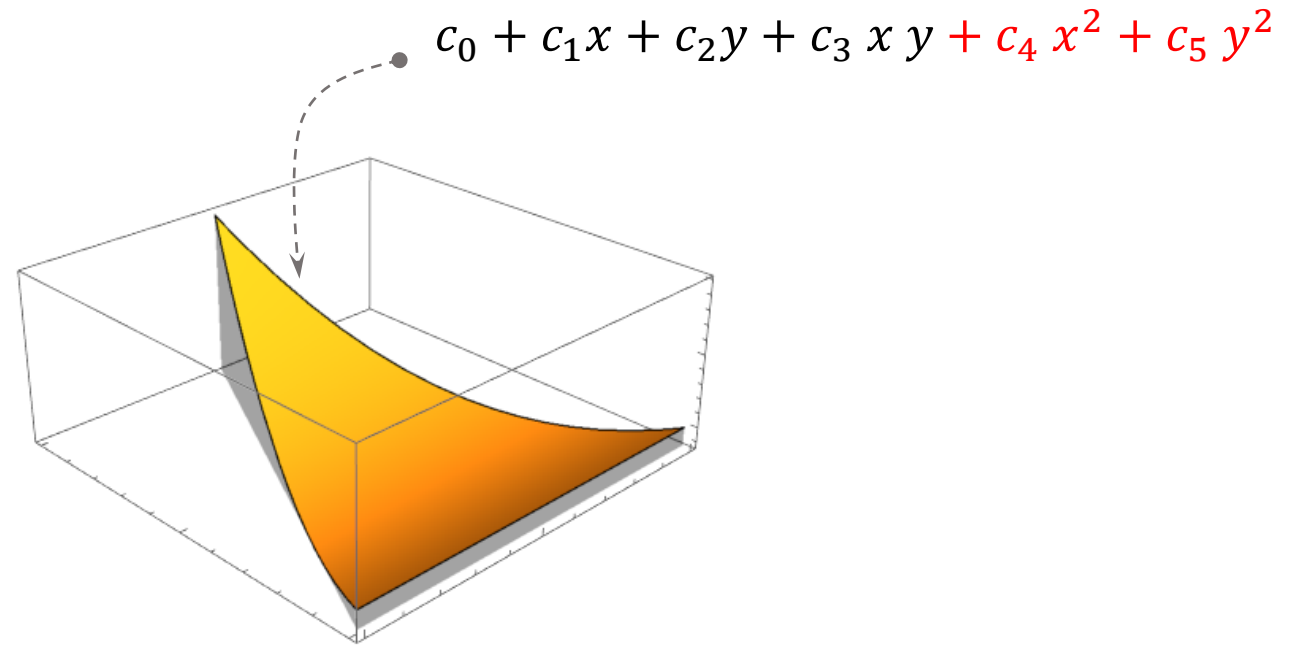
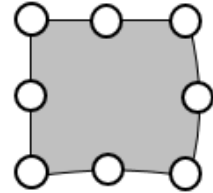
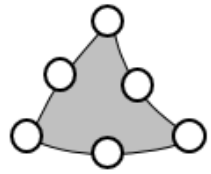
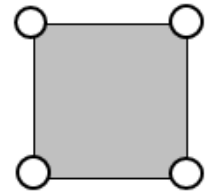
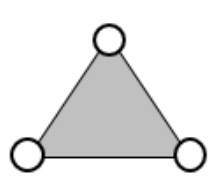
2D Elements



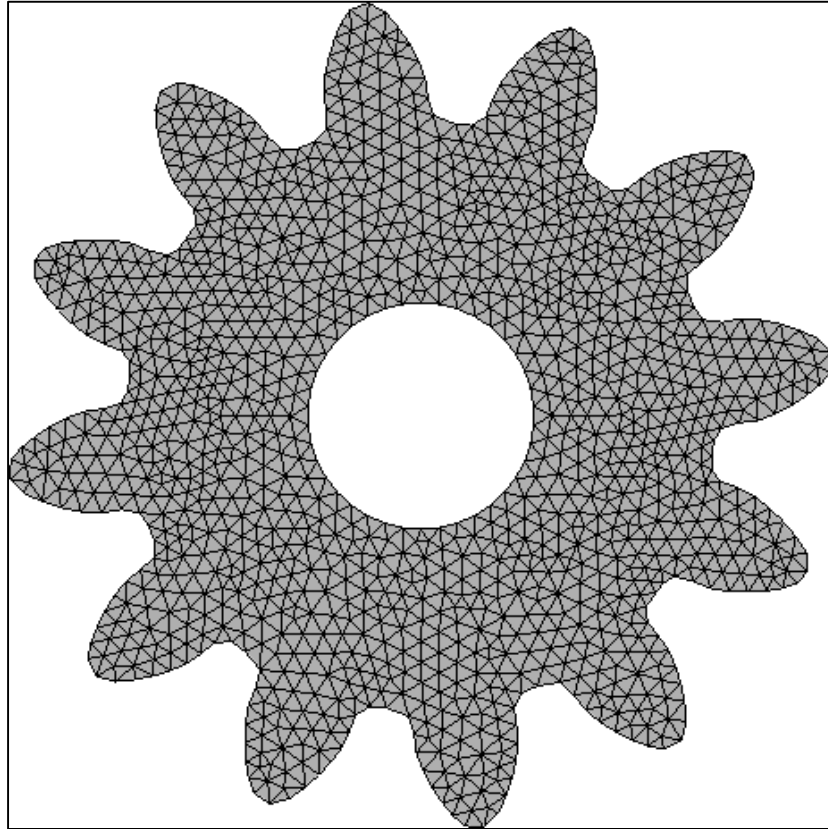
2D Elements

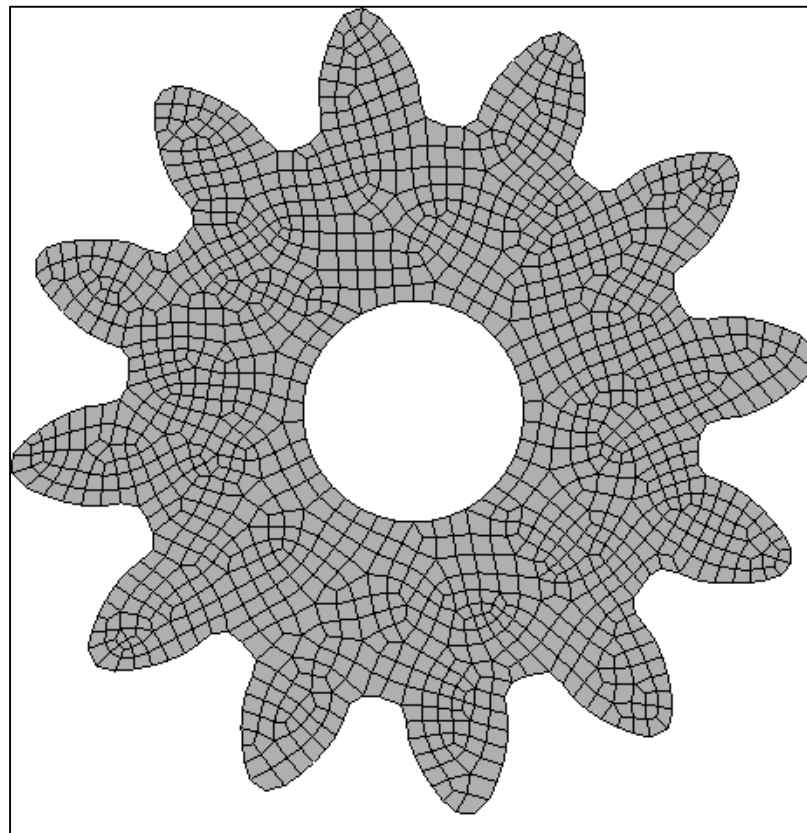
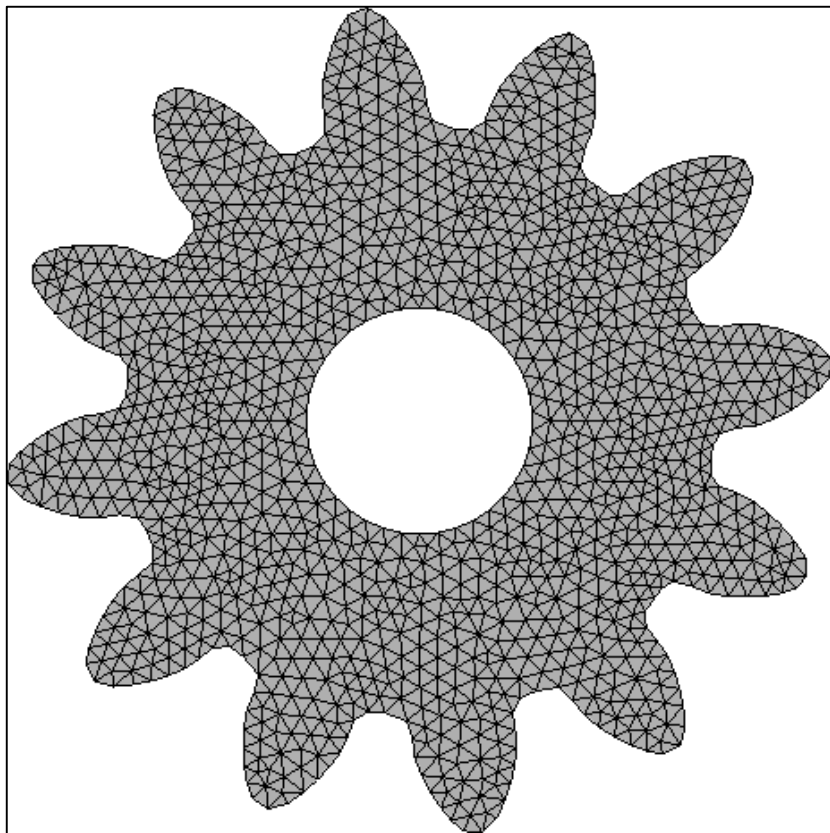


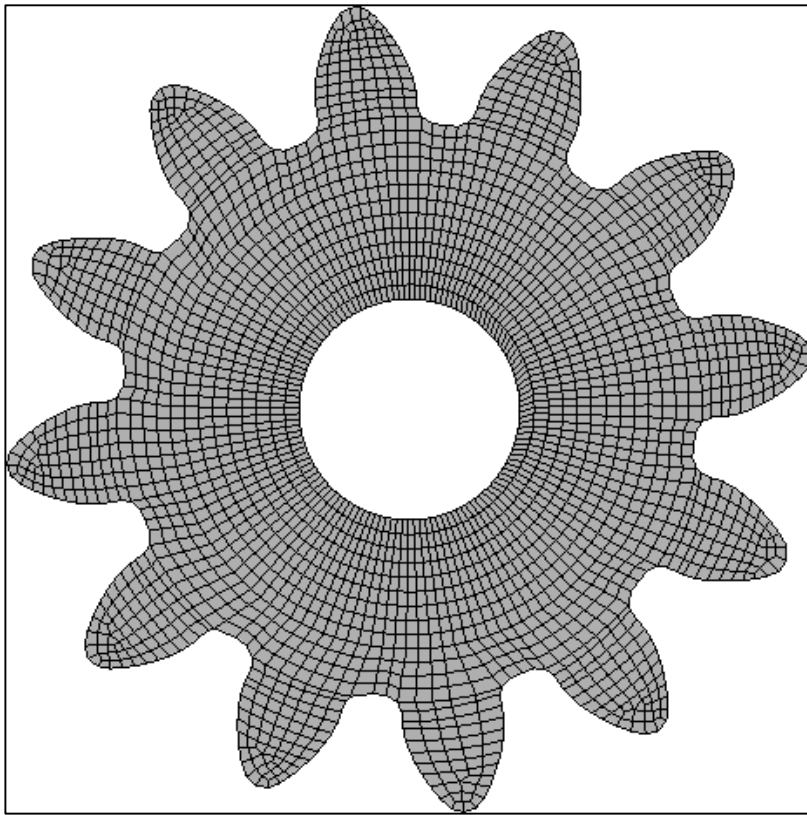
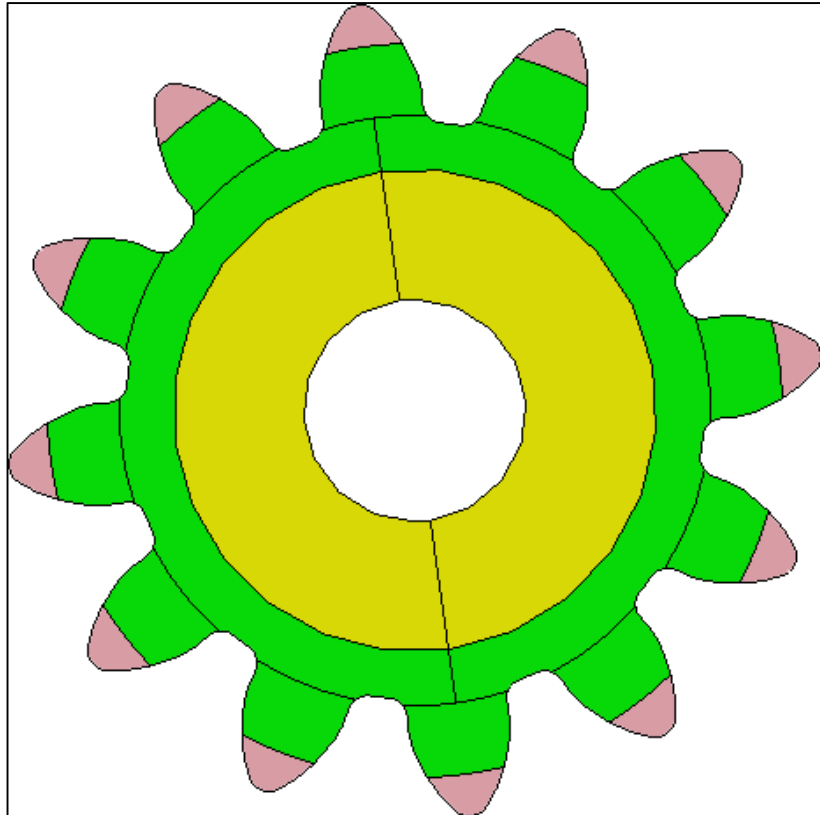
2D Elements

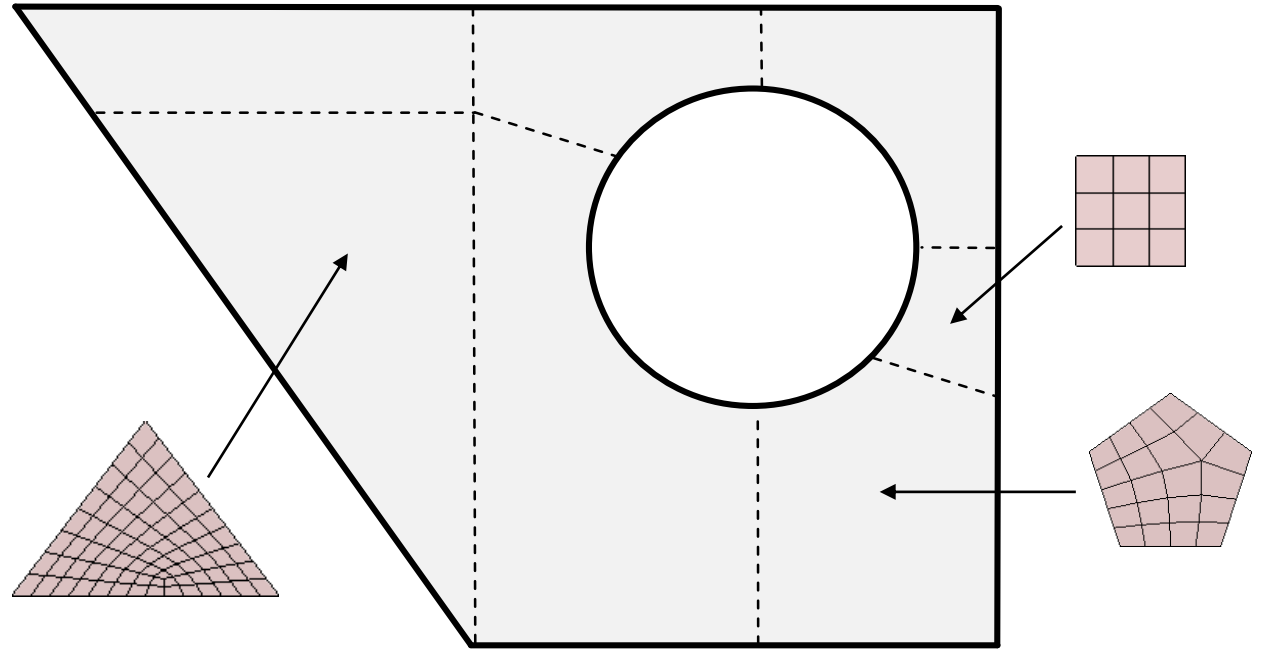
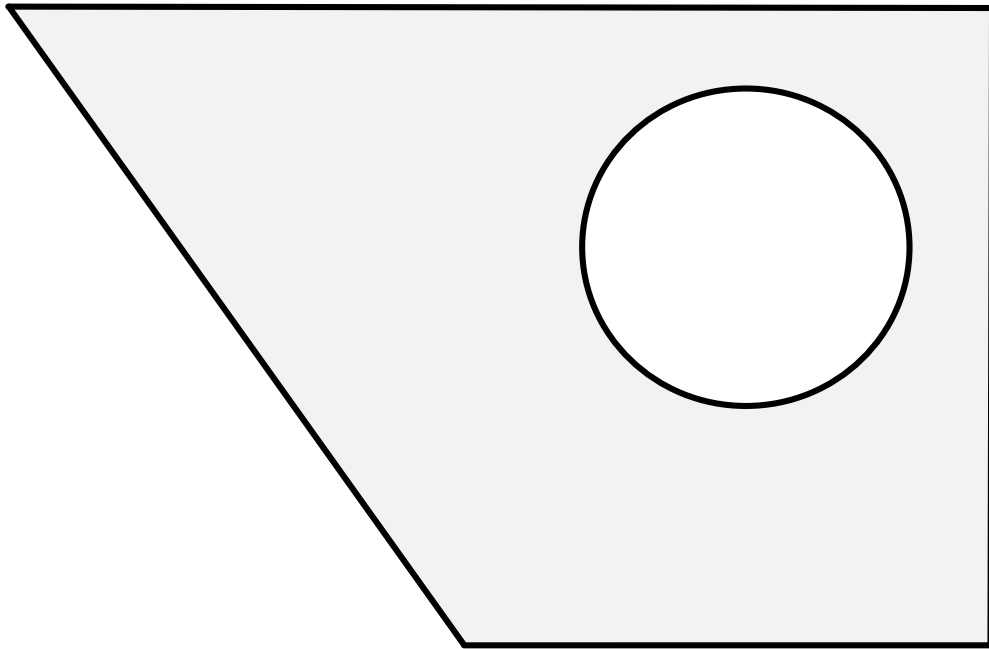


2D/Shell Meshing

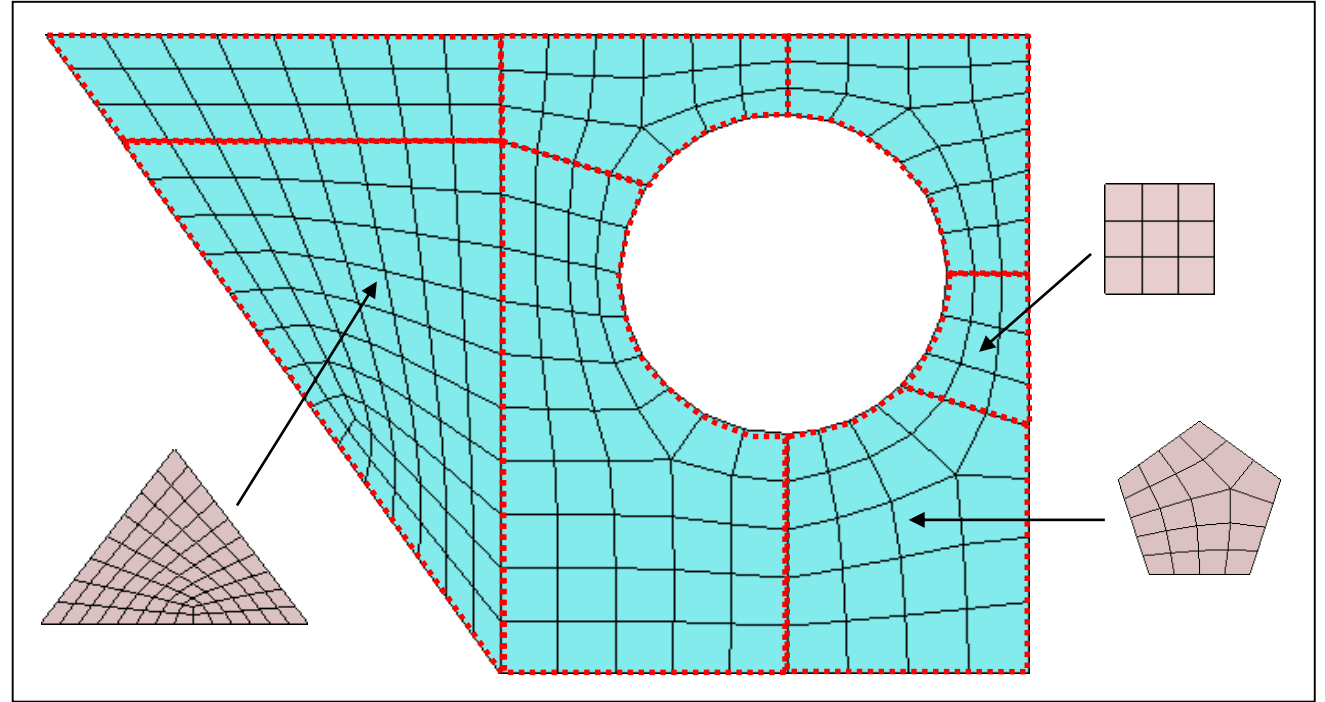
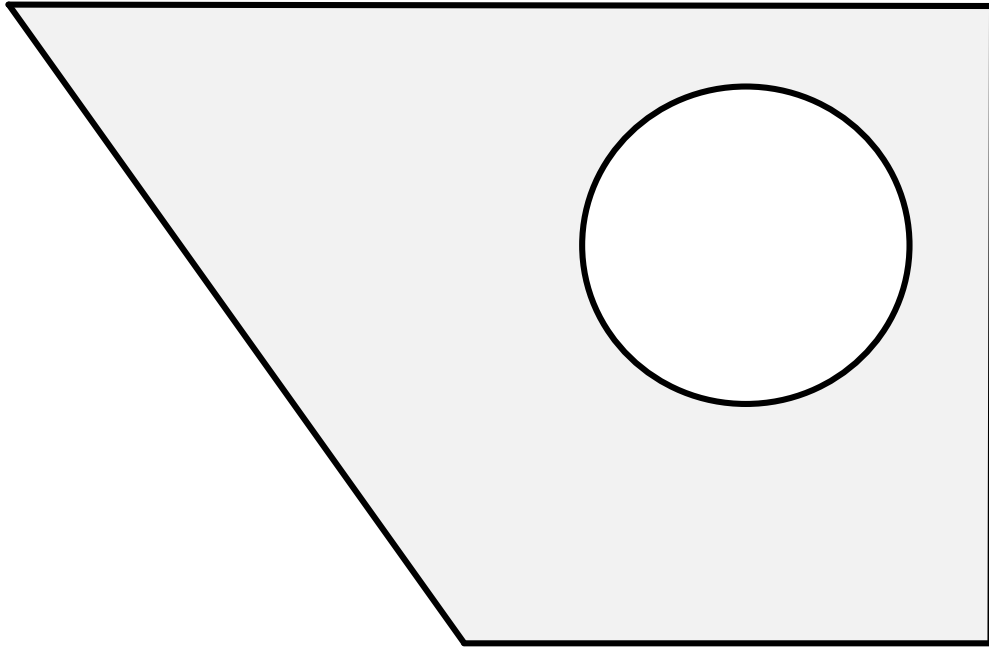


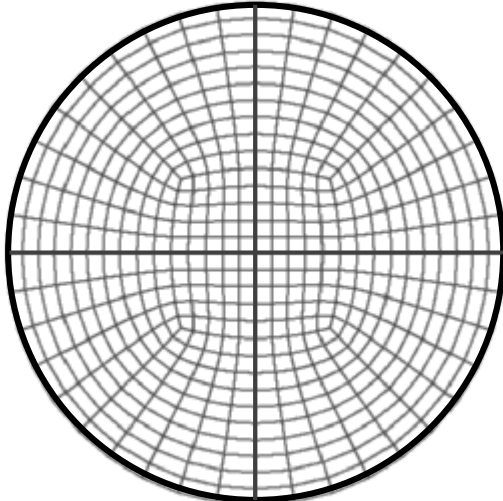
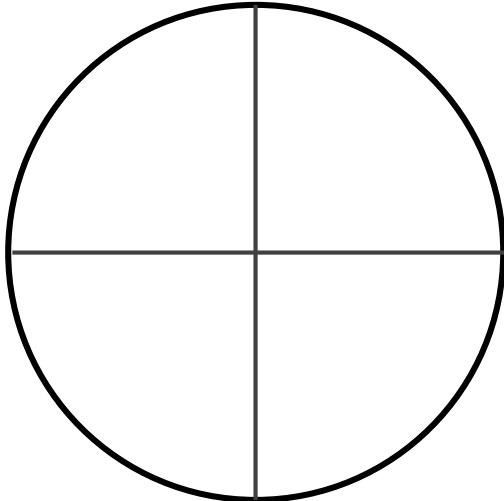
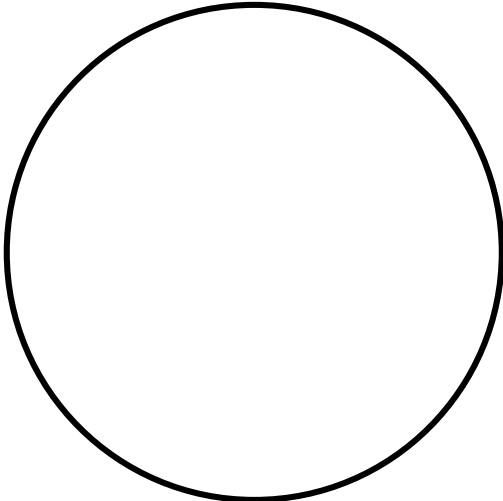




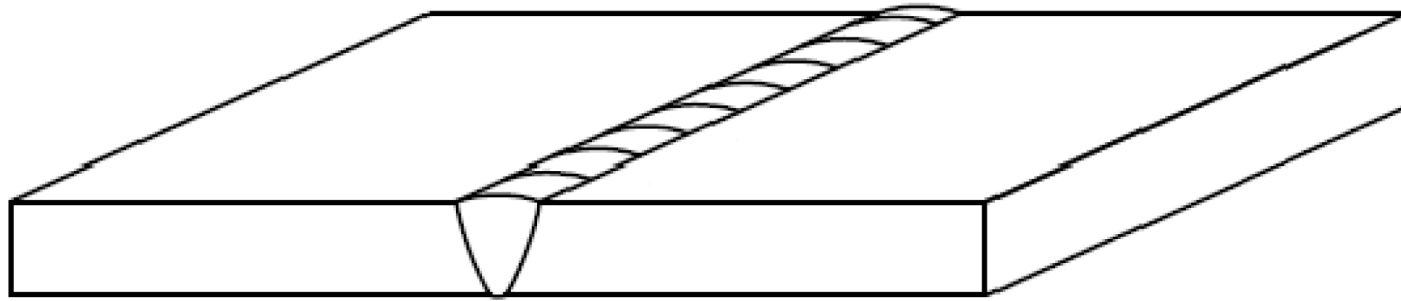


2D/Shell Meshing

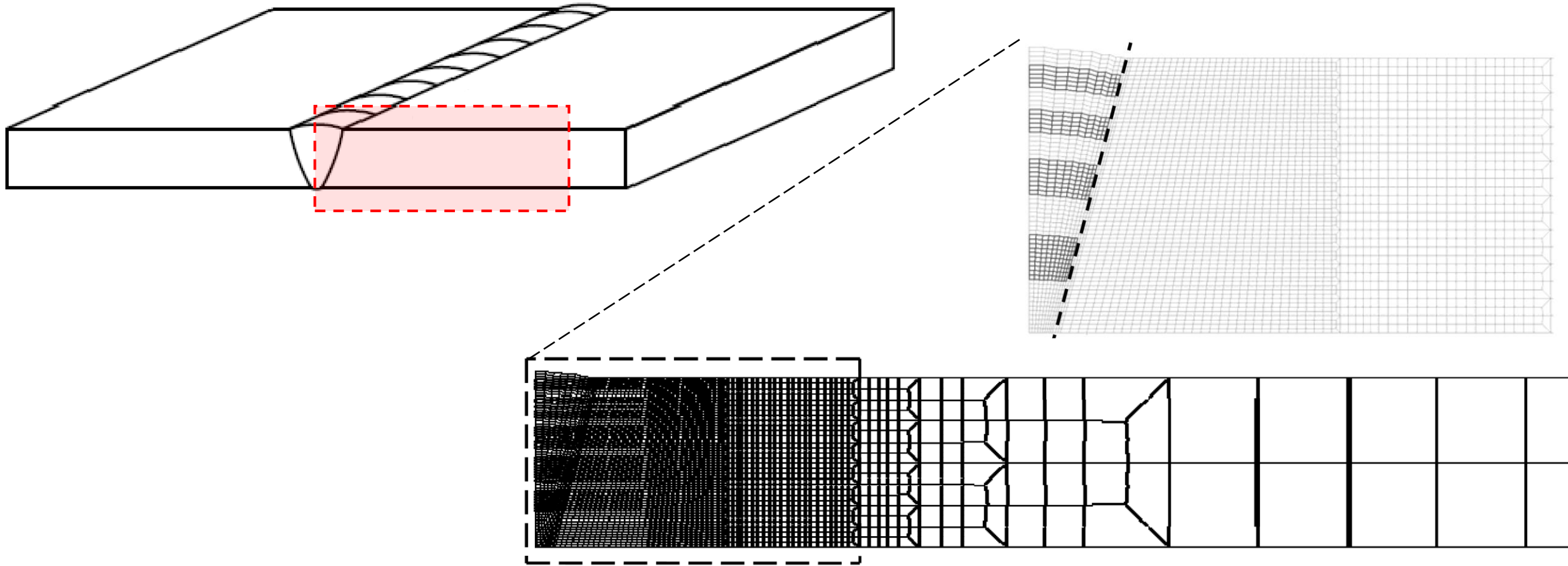




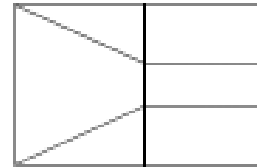
2D/Shell Meshing



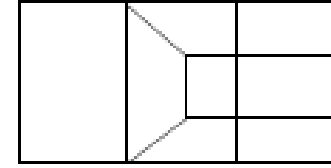
2D/Shell Meshing



Mesh transition techniques and flow lines



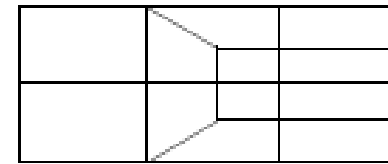
1 to 3



1 to 3



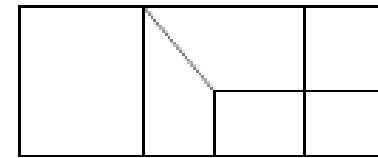
2 to 4



2 to 4



1 to 2



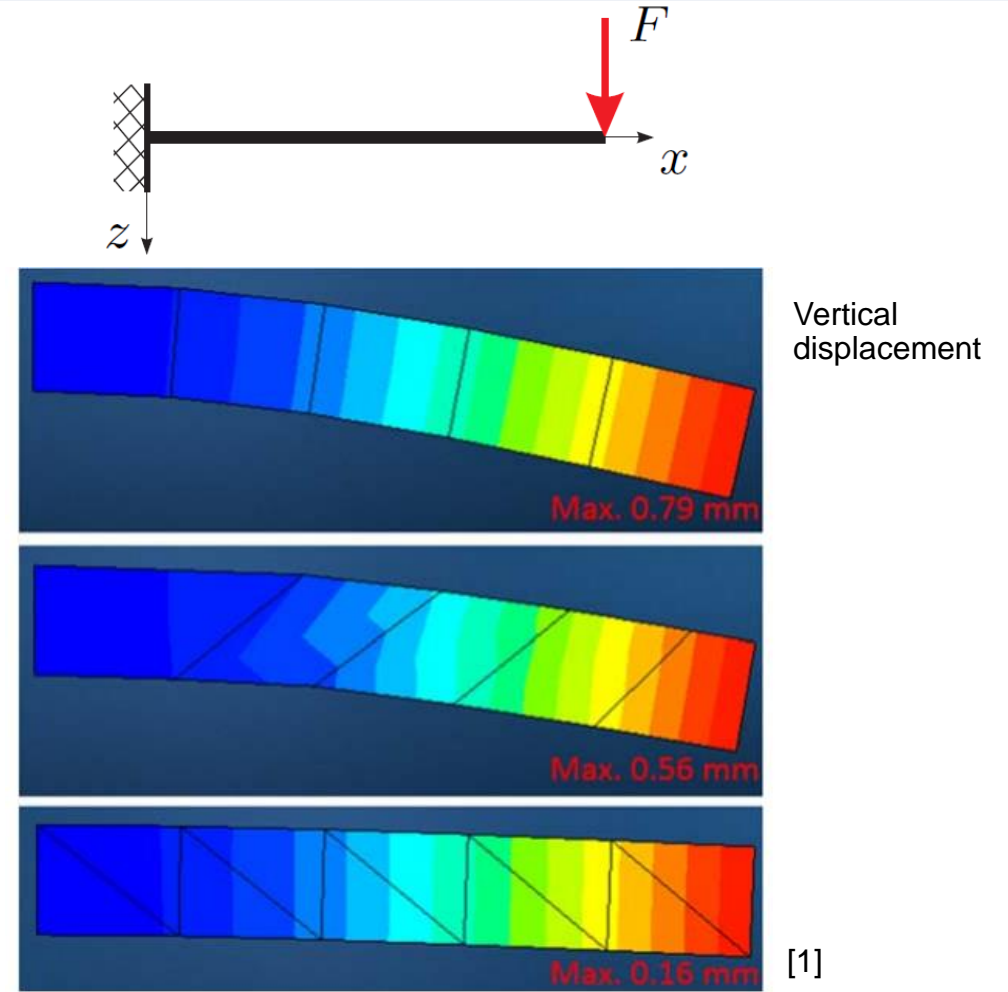
1 to 2 x 2

[1]

[1] Introduction to meshing, available at: <https://altairuniversity.com/wp-content/uploads/2014/02/meshing.pdf>

2D Mesh Quality

- Aspect ratio
- Maximum and minimum angle
- Skewness
- Jacobian

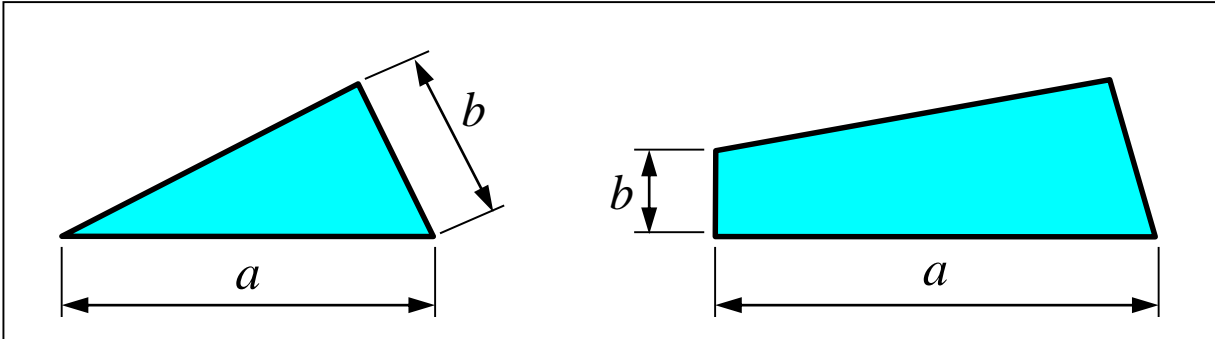


[1] Available at: https://www.mscsoftware.com/sites/default/files/whitepaper_how_to_create_a_good_fe_model.pdf

- **Aspect ratio**
- Maximum and minimum angle
- Skewness
- Jacobian

$$1 \leq f_r = \frac{a}{b} \leq \infty, a \geq b$$

$$f_{rmax} \leq 5$$



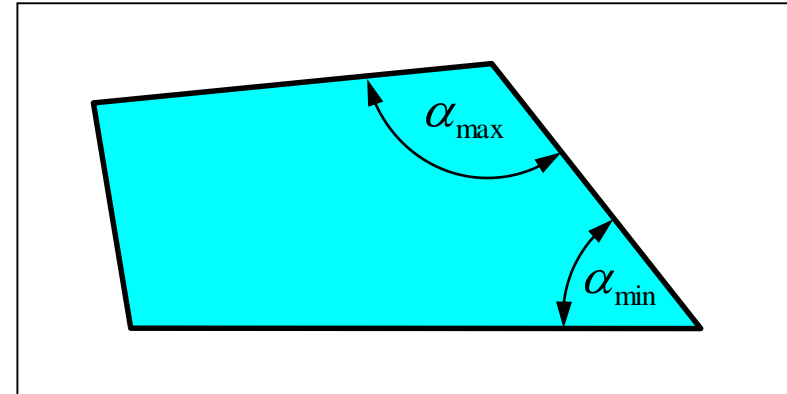
2D Mesh Quality

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- **Maximum and minimum angle**
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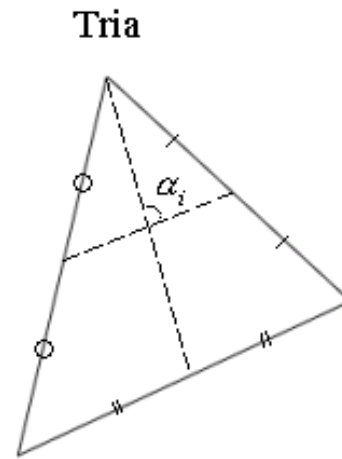
$$0^\circ \leq \alpha \leq 180^\circ$$

$$45^\circ \leq \alpha_{\min}$$

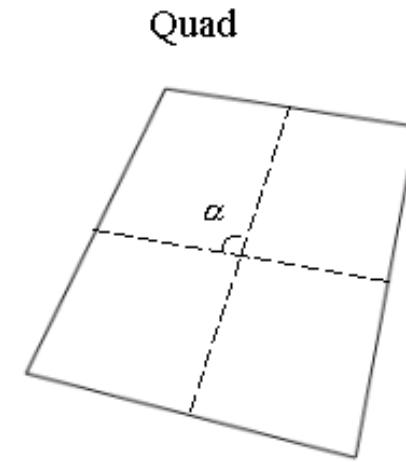
$$\alpha_{\max} \leq 135^\circ$$



- Aspect ratio
- Maximum and minimum angle
- **Skewness**
- Jacobian



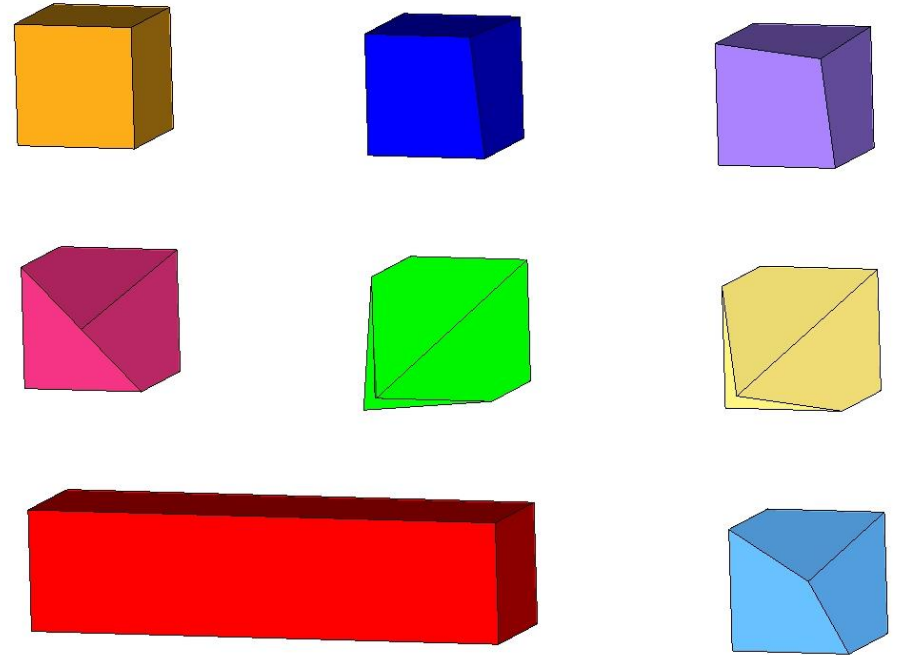
$$\text{Skew Angle} = 1 - \text{Max} \left(\frac{90^\circ - \alpha_i}{90^\circ} \right)$$



$$\text{Skew Angle} = 1 - \left(\frac{|90^\circ - \alpha|}{90^\circ} \right) \quad [1]$$

[1] Available at: <https://www.mechead.com/mesh-good-enough/>

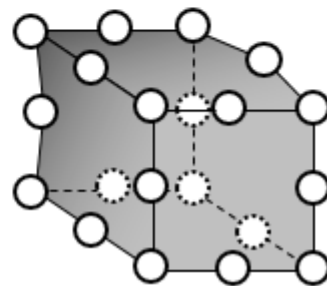
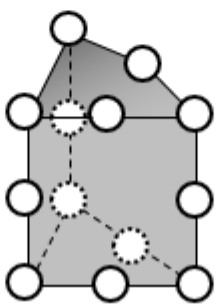
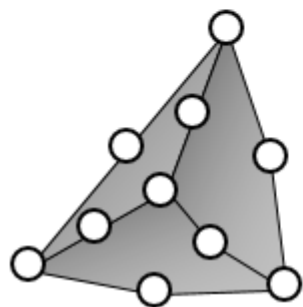
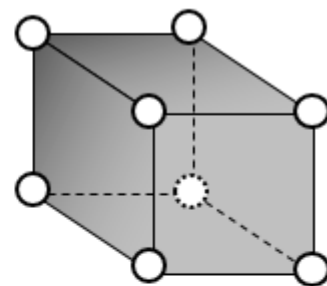
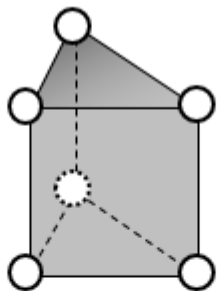
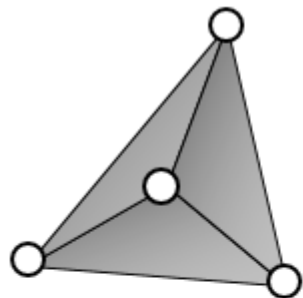
- Aspect ratio
- Maximum and minimum angle
- Skewness
- **Jacobian**



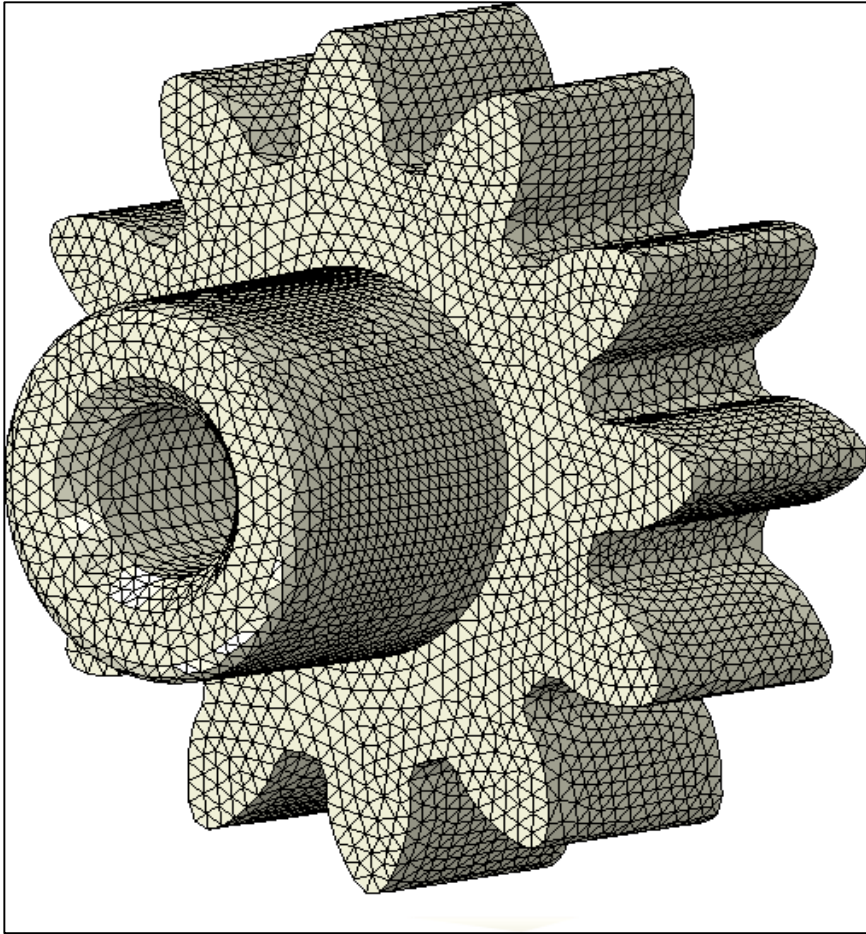
Jacobians (J):
Orange Cube $J = 1.0$
Blue $J = .942$
Purple $J = .883$
Pink $J = .398$
Green $J = -.409$
Tan $J = -.130$
Red $J = 1.0$
Light Blue $J = .072$

[1]

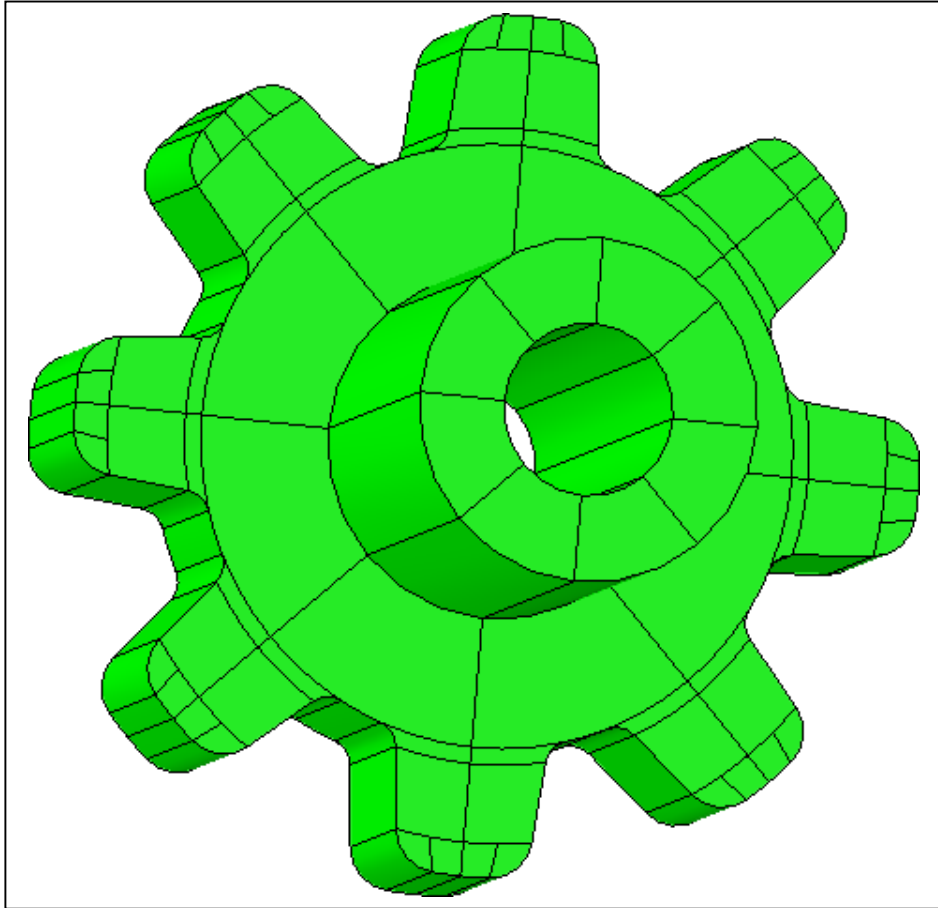
[1] Available at: <http://www.isaiahjanzen.com/2012/08/the-jacobian-finite-element-mesh-quality.html?m=1>



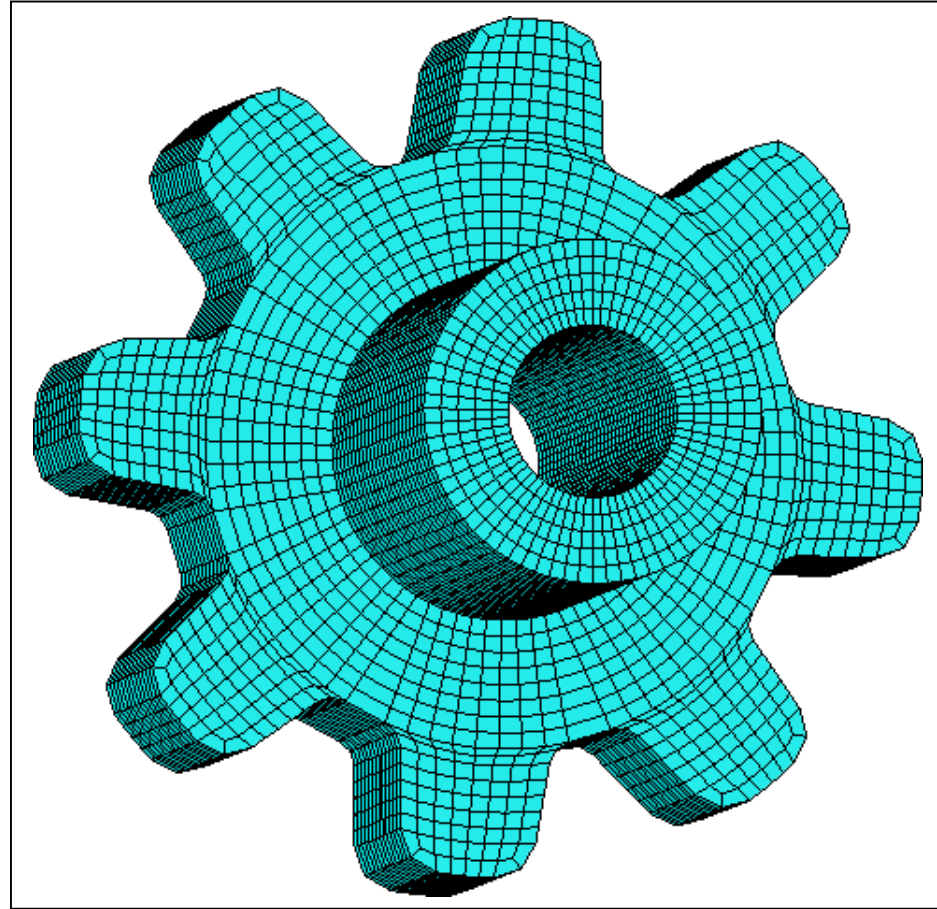
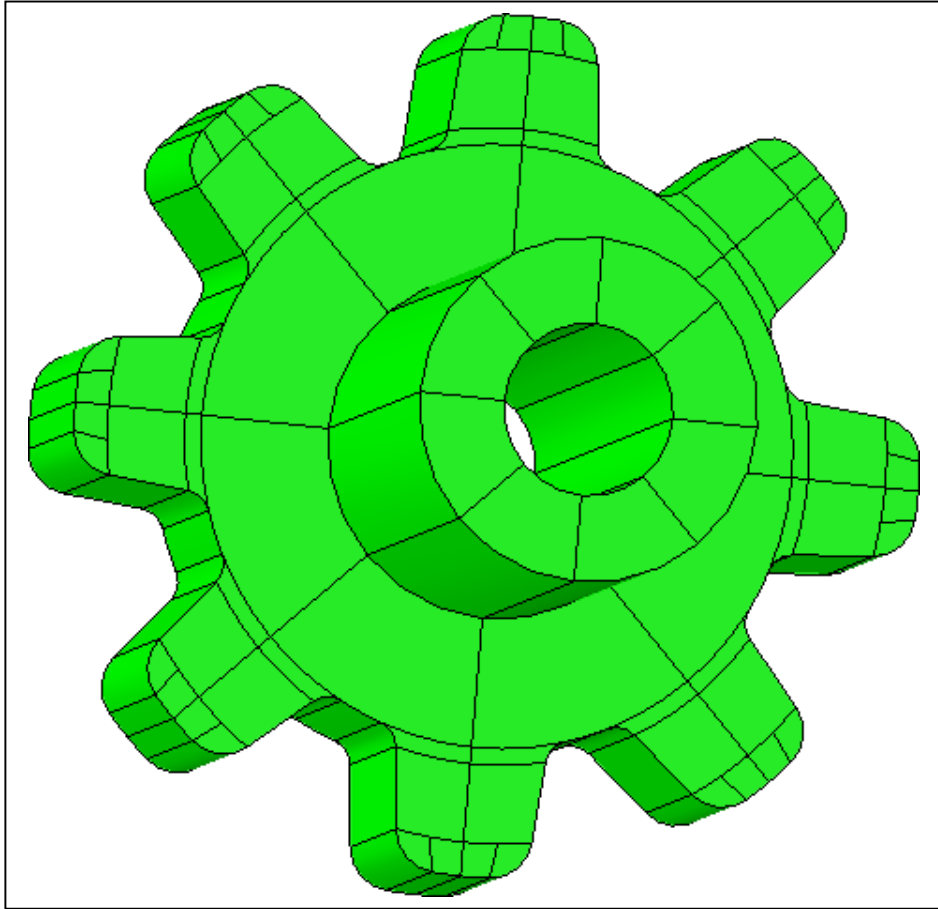
3D Meshing

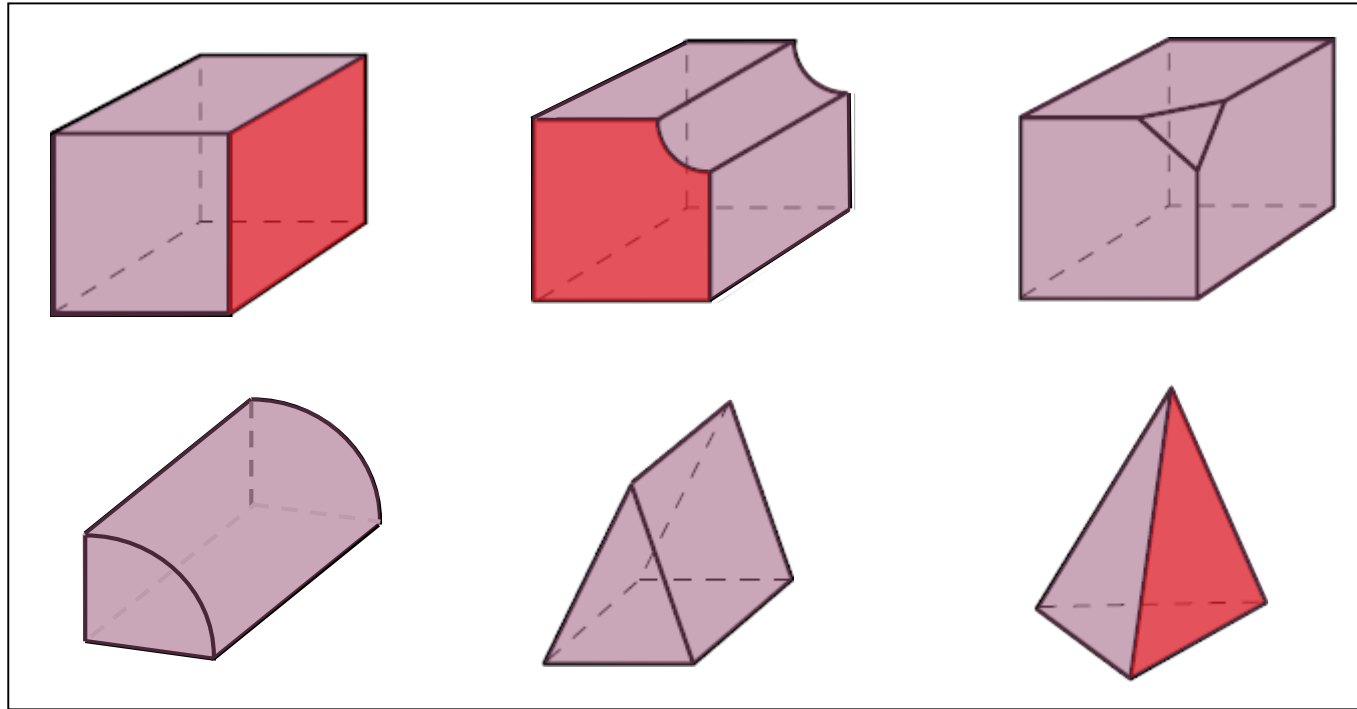


3D Meshing

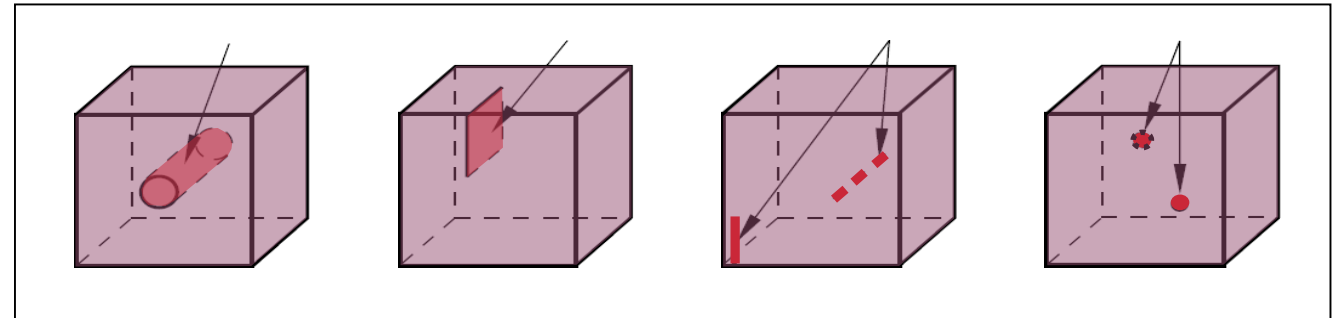
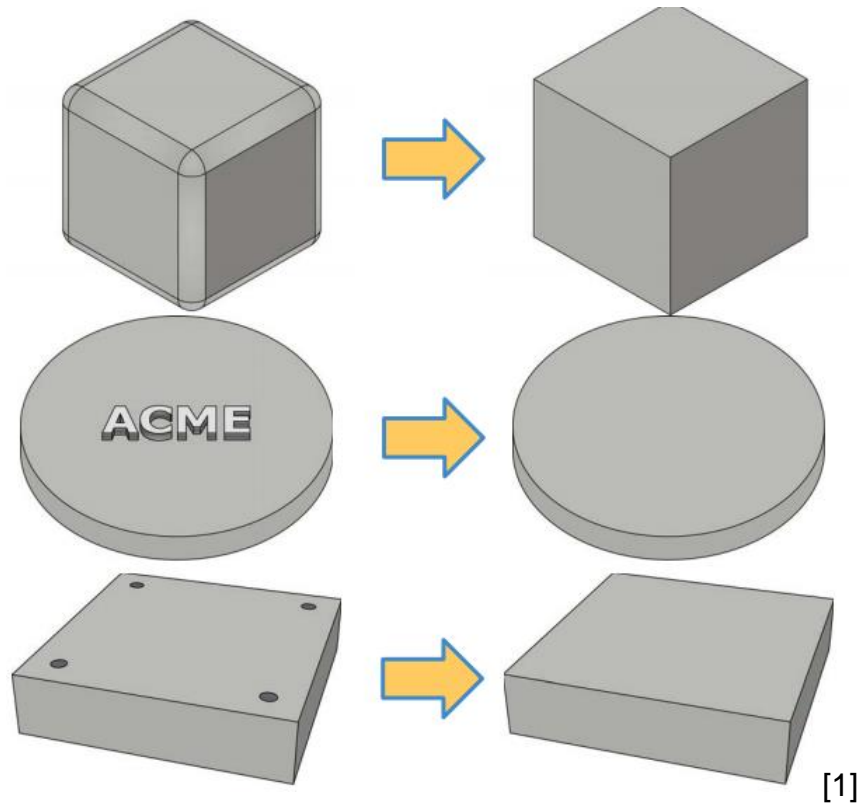


3D Meshing



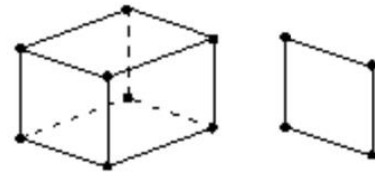


Making a good mesh



[1] Available at: http://ehf2018.iusiani.ulpgc.es/courses_files/JSarrate-Course.pdf

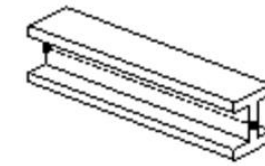
- Family
- Degrees of Freedom
- Number of Nodes
- Formulation
- Integration



Continuum
(solid) elements



Shell
elements



Beam
elements



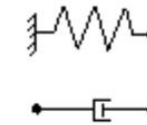
Rigid
elements



Membrane
elements



Infinite
elements



Springs and dashpots

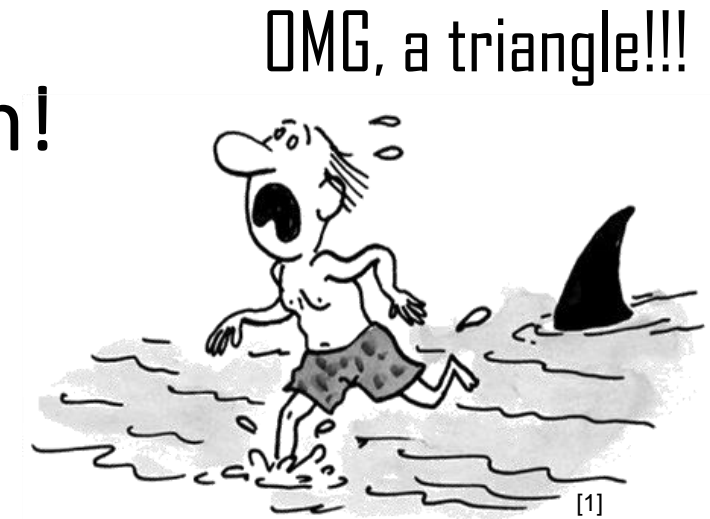


Truss
elements

[1]

Thank you for your attention!

<http://sctrain.eu/>



[1] <https://www.cartoonstock.com/cartoon?searchID=CX305112>

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OF OSTRAVA

IT4INNOVATIONS
NATIONAL SUPERCOMPUTING
CENTER



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