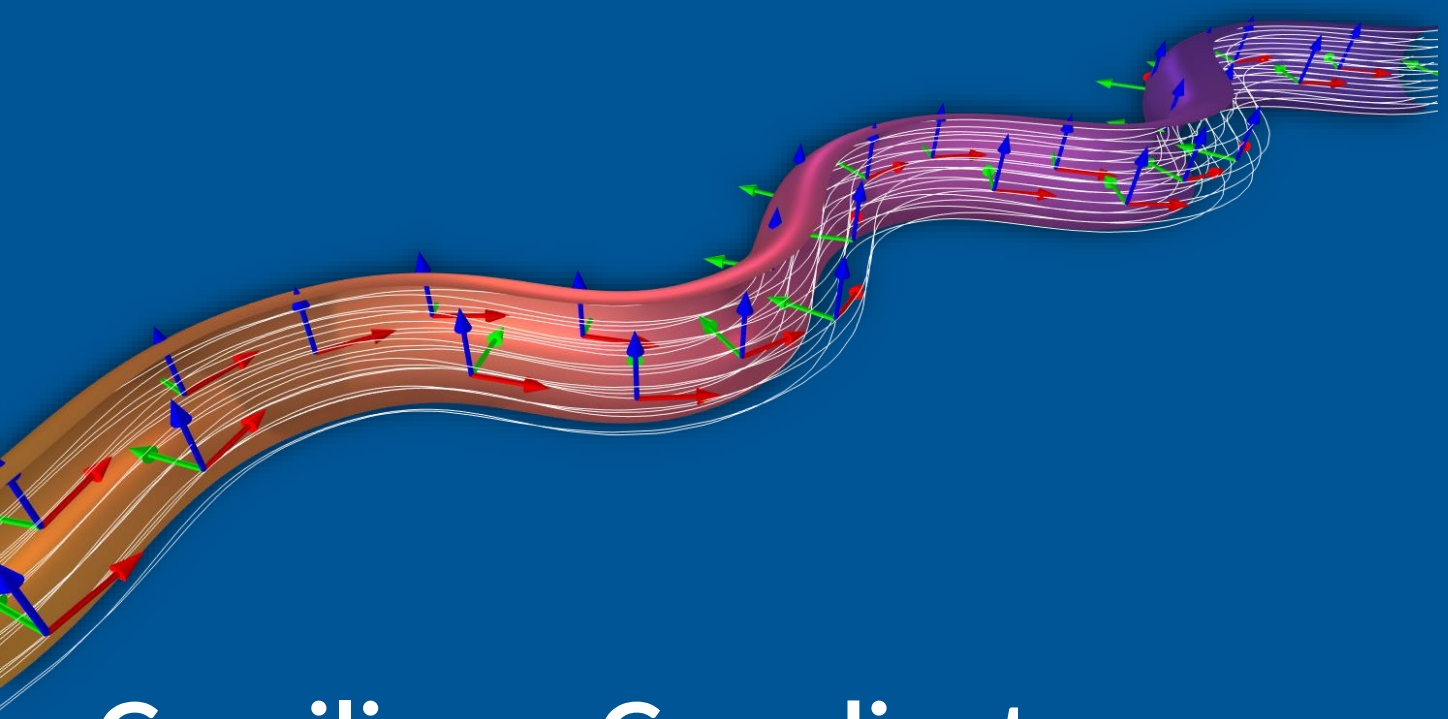
COMSOL Day
Fluids & Heat

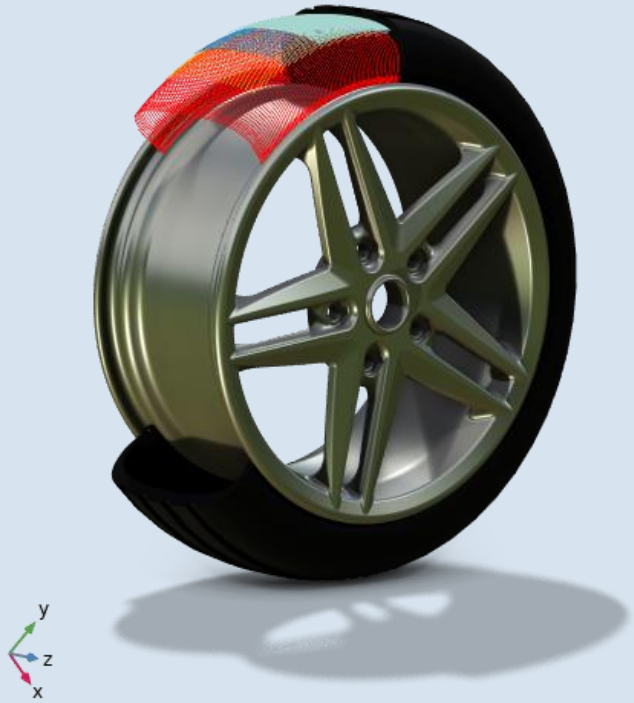


Curvilinear Coordinates

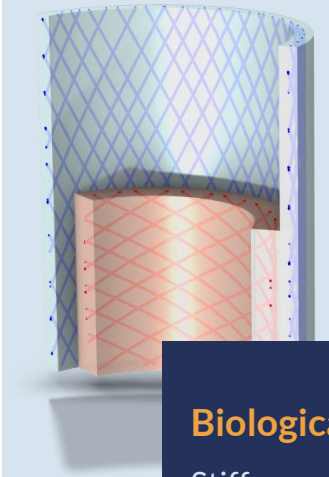
Nancy Bannach
Development Manager,
COMSOL

Coordinate Systems

How to set up and use different coordinate systems in COMSOL.

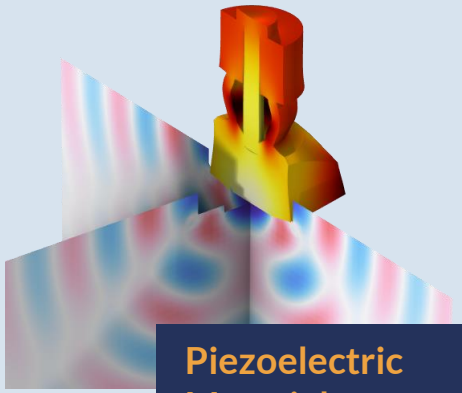


Application Areas



Biological Tissue

Stiffness of muscle tissue (fibers) or arterial walls depend on direction.



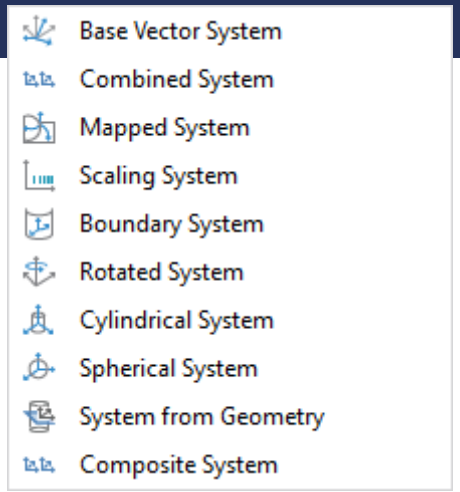
Piezoelectric Material

Materials have direction dependent properties. Align coordinate system with crystal axes or polarization direction.

Composites

Composites often have anisotropic properties (e.g. fibers). Especially in layered structures these often vary for each layer.

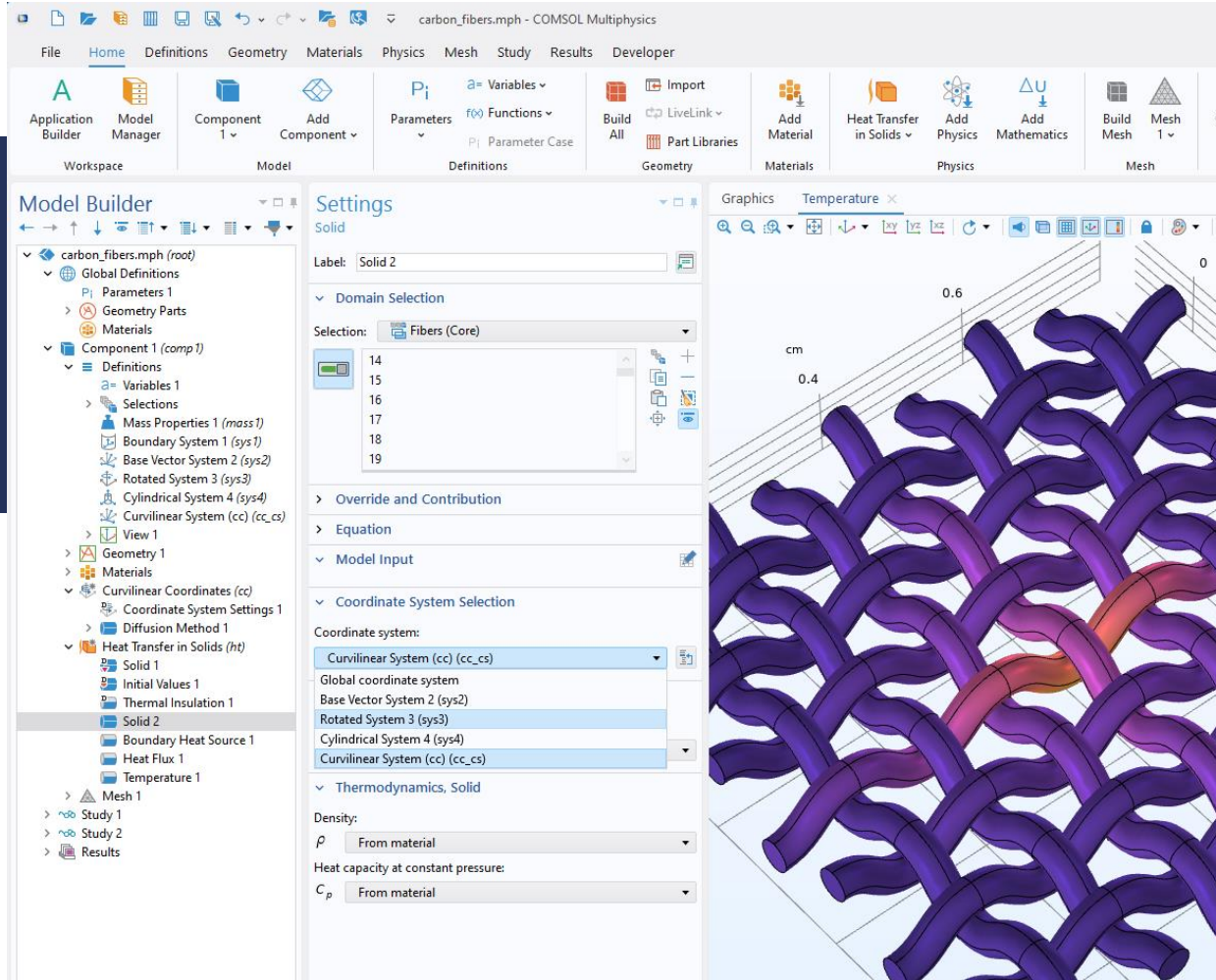
Coordinate Systems in COMSOL



- Global cartesian coordinate system shown in Graphics window
- User-defined coordinate systems can be used to define material properties or for physics settings.
- COMSOL uses global system to solve the equations
- Coordinate system transformations are done automatically

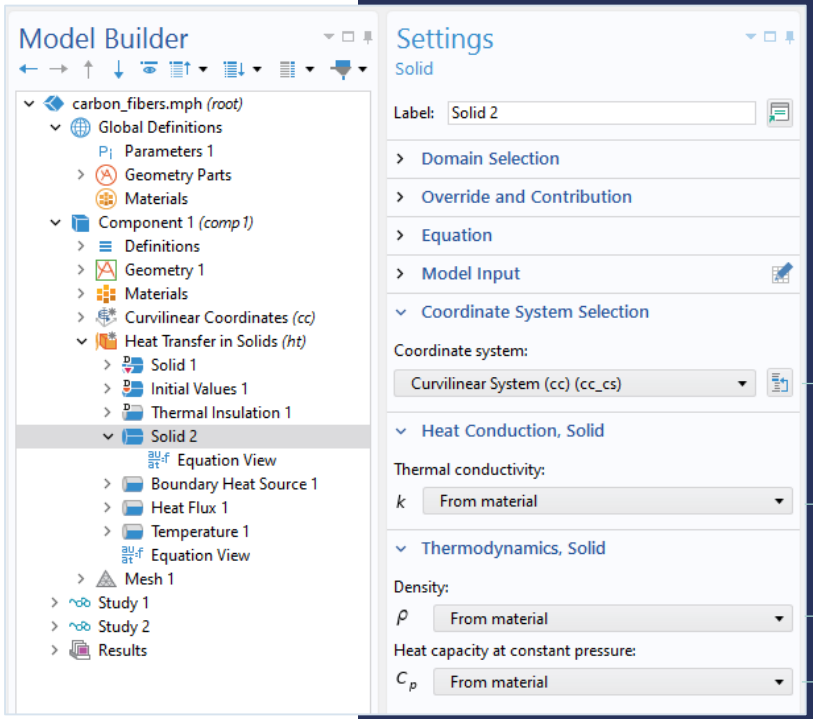
Use Coordinate Systems in Physics Features

- The selected coordinate systems will be used for all tensor or vector inputs
- COMSOL automatically computes the transformation to the global system



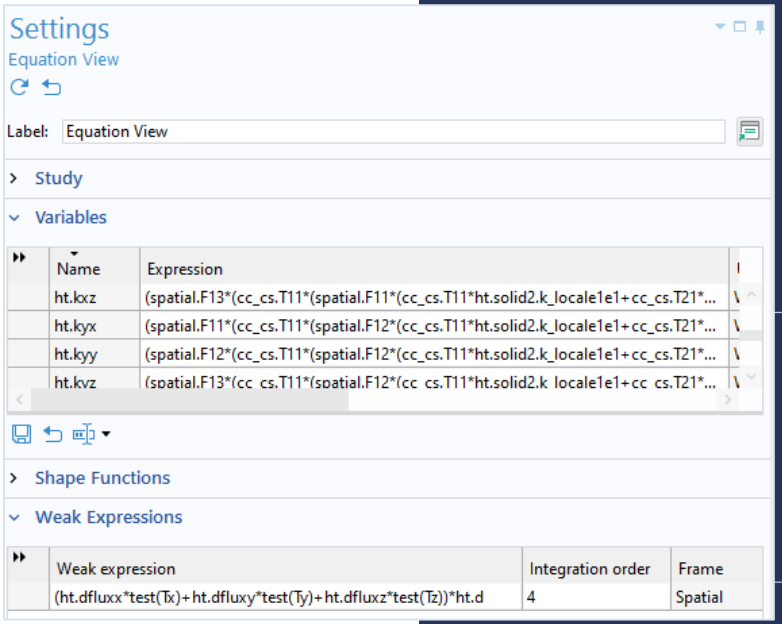
Example: Heat Transfer

- Input of user-defined coordinate systems is only available in features that can make use of it
- Use the coordinate system to define the thermal properties
- Tensor-valued properties automatically use the selected coordinate system
- Scalar values are not affected



Example: Heat Transfer

- Which equations and variables are computed can be inspected in the equation view
- Variables are transformed automatically into global system
- Equations and other variables are not transformed

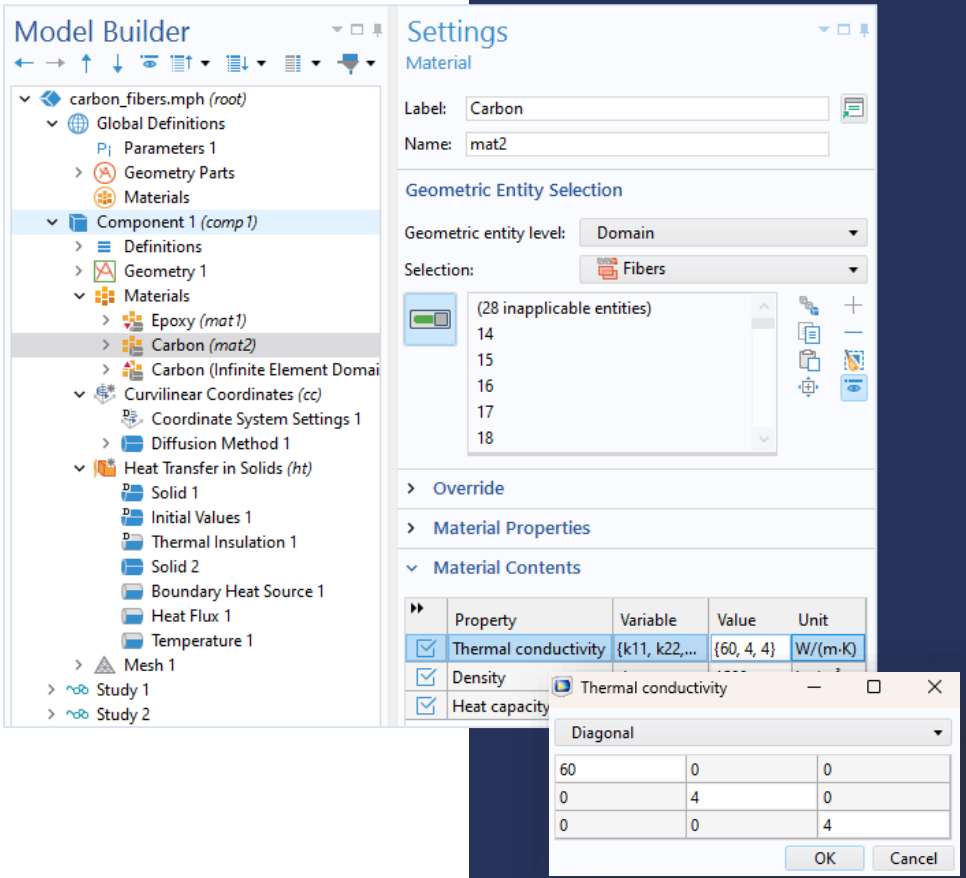


Computation of thermal conductivity tensor components

Equation to solve

Thermal Conductivity

- Define components of thermal conductivity (isotropic, diagonal, symmetric, full)
- Which coordinate system is used is determined by the physics feature.

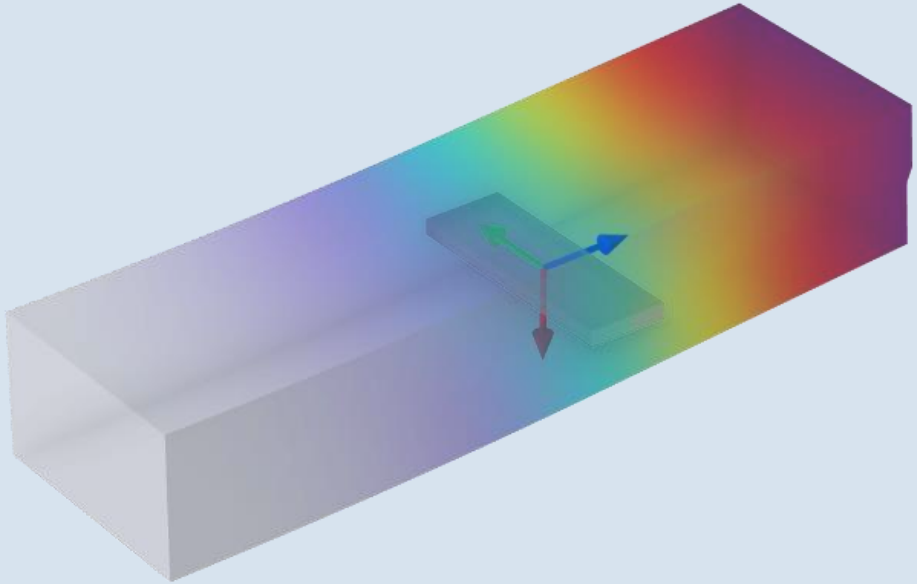


COMSOL

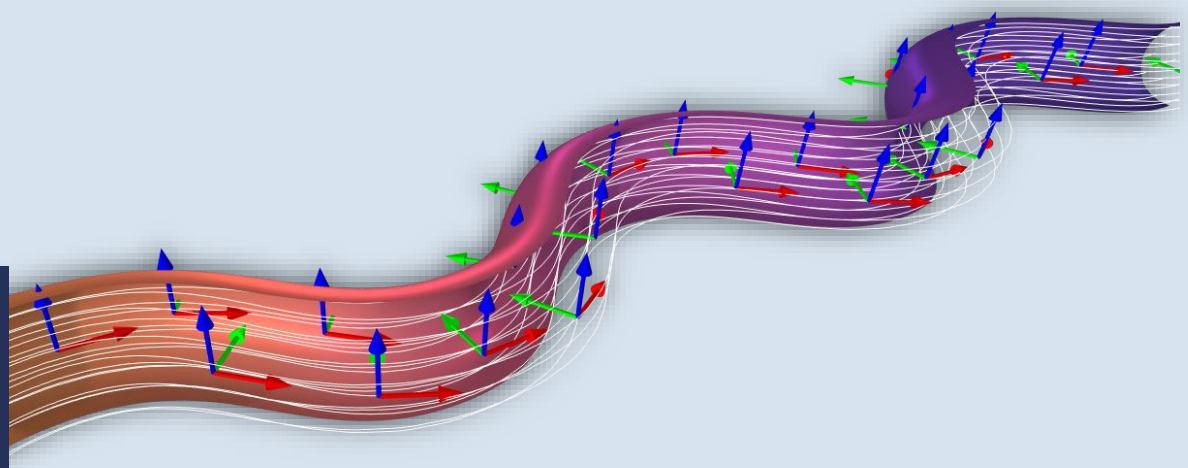
DEMO

Piezoelectric Actuator

How to use and set up different coordinate systems.



COMSOL

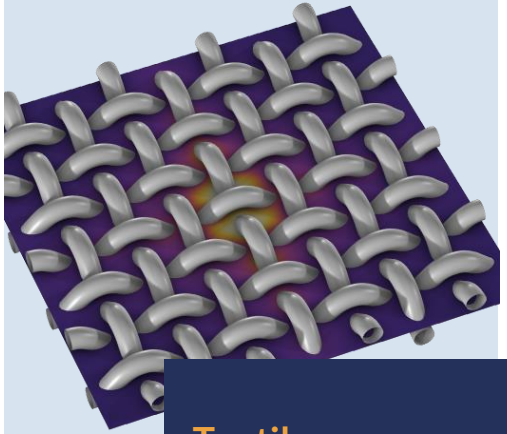


FOLLOW SHAPE

Curvilinear Coordinates

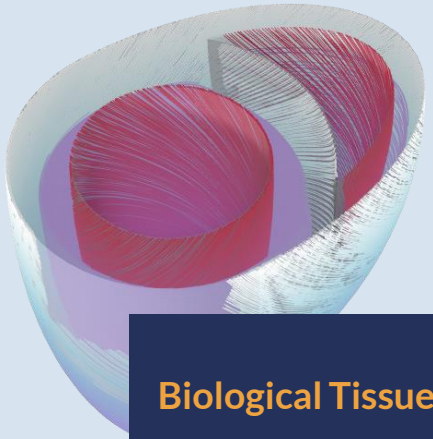
Compute a coordinate system if a basic coordinate system is too difficult to use, e.g. for fibrous material in complex shapes

Application Areas



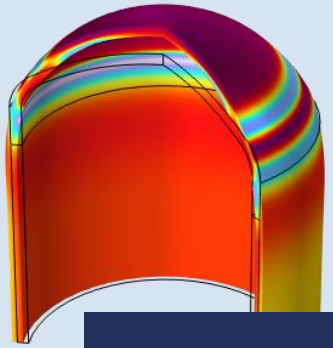
Textiles

Woven fabric, where properties are aligned with the fiber direction.



Biological Tissue

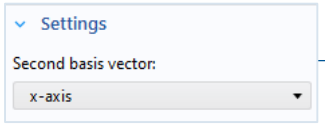
Muscle tissue around heart has anisotropic properties aligning with fiber orientation.



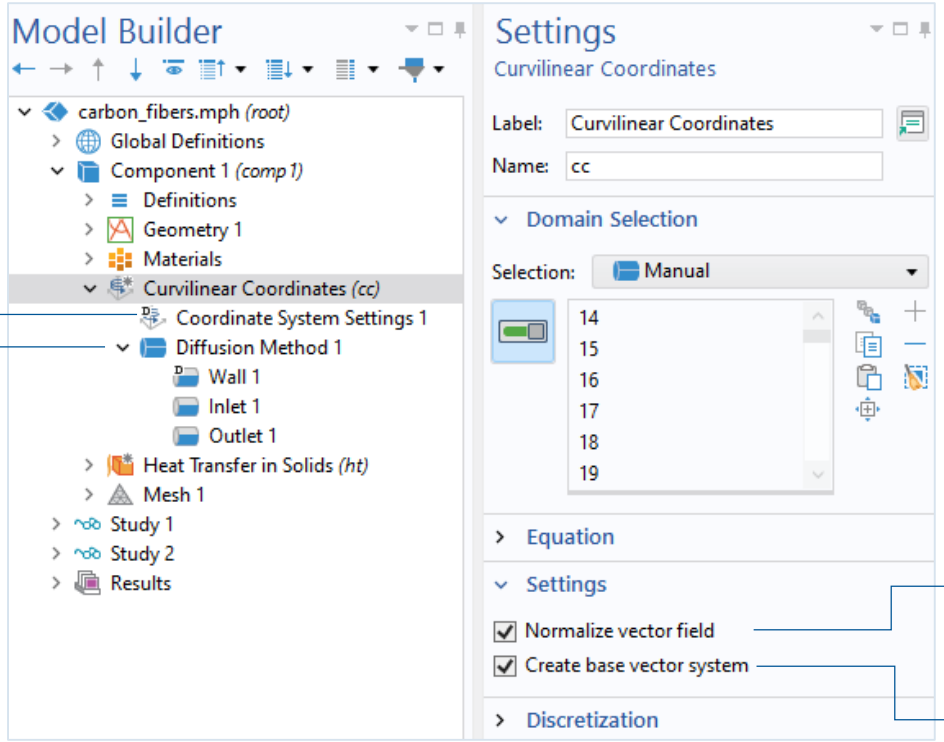
Composites

Rolled steel sheet has different mechanical directions in out-of-plane direction

First basis vector is defined by the solution of the equation (gradient).



Selected Method



Normalize vector field (default) to prevent scaling effects

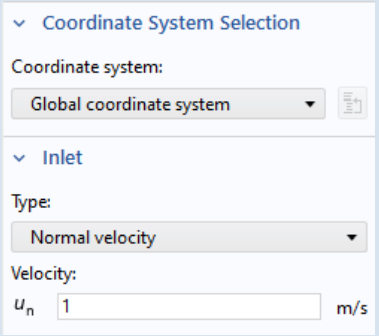
To define a coordinate system under **Definitions**

Inlet

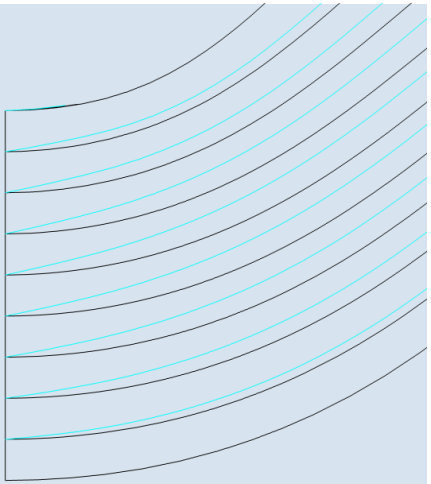
- Defines starting of the vector field
- Settings differ for different methods.

Outlet

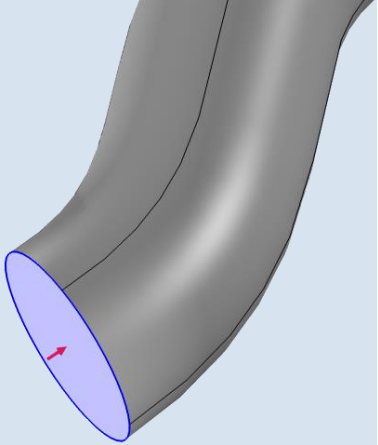
- Defines end of vector field



Flow method allows using other coordinate systems to define direction.

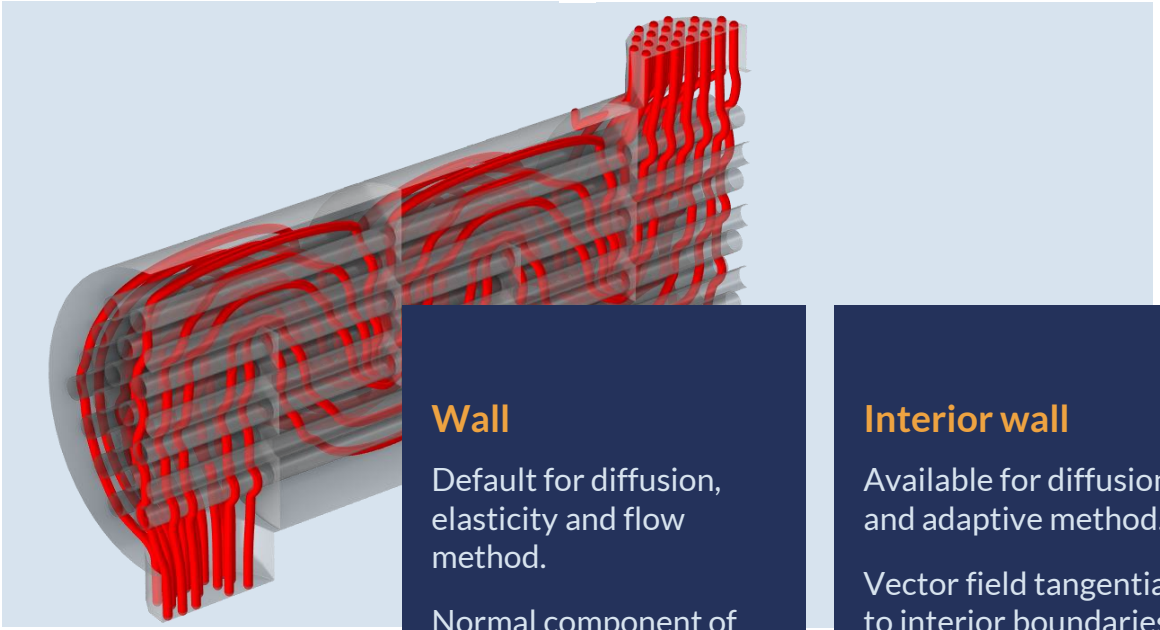


Flux (blue) or constraint (black) inlet for diffusion method



Vector field enters orthogonally in the adaptive method.

Wall, Interior Wall, Jump



Wall

Default for diffusion, elasticity and flow method.

Normal component of vector field is zero.

Interior wall

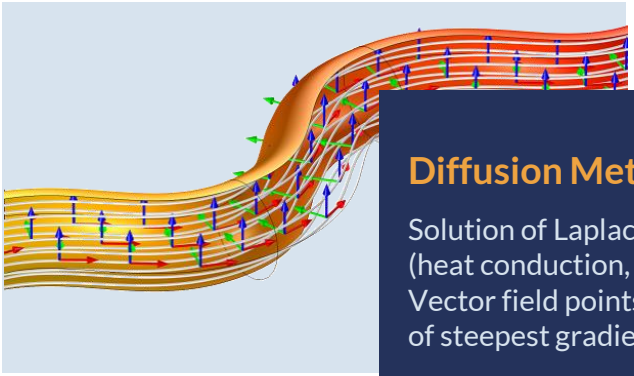
Available for diffusion and adaptive method.

Vector field tangential to interior boundaries.

Jump

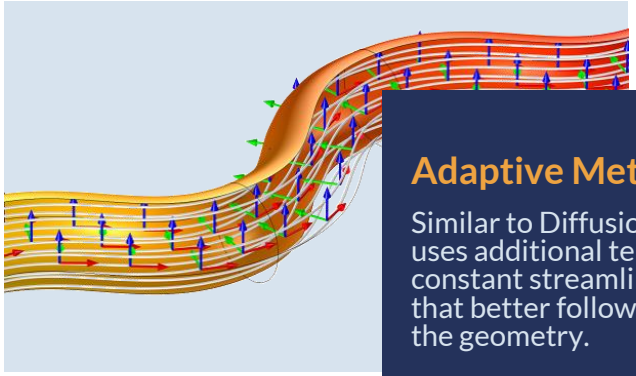
For closed-loop vector fields.

Methods



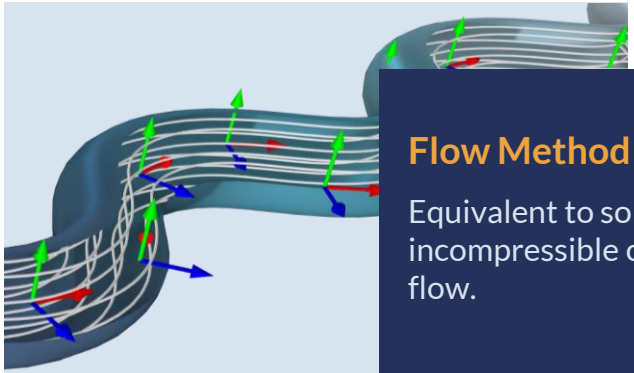
Diffusion Method

Solution of Laplace's equation (heat conduction, diffusion). Vector field points in direction of steepest gradient.



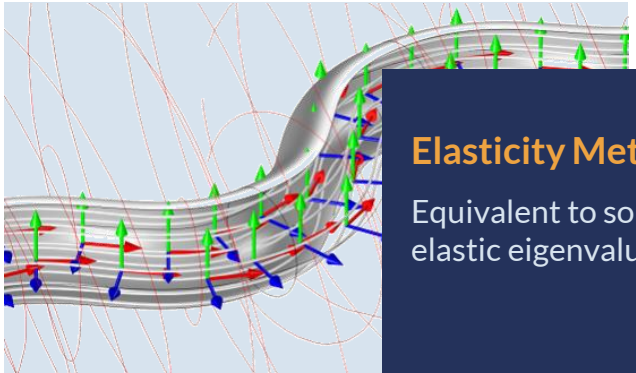
Adaptive Method

Similar to Diffusion method but uses additional terms for more constant streamline density that better follows the shape of the geometry.



Flow Method

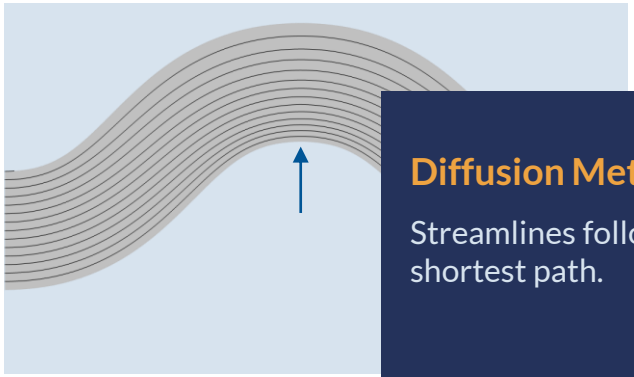
Equivalent to solving incompressible creeping flow.



Elasticity Method

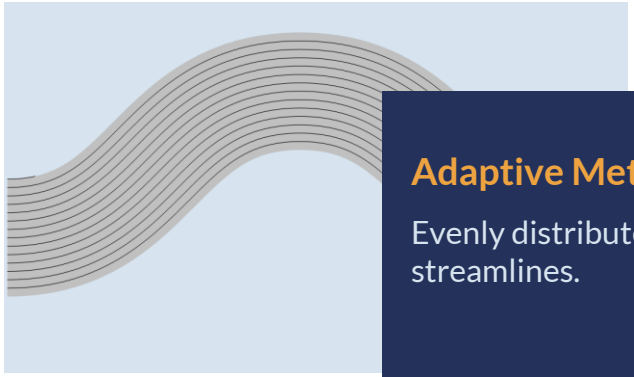
Equivalent to solving a linear elastic eigenvalue problem.

Curvature



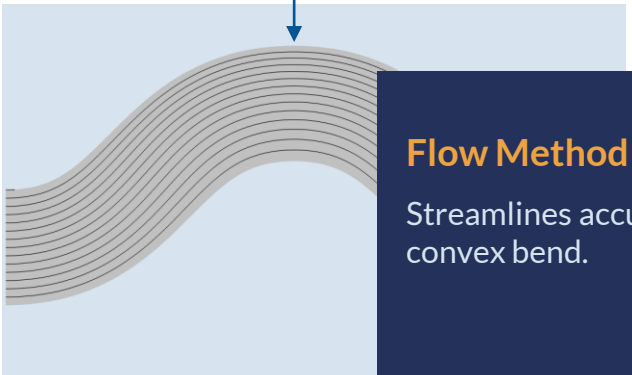
Diffusion Method

Streamlines follow the shortest path.



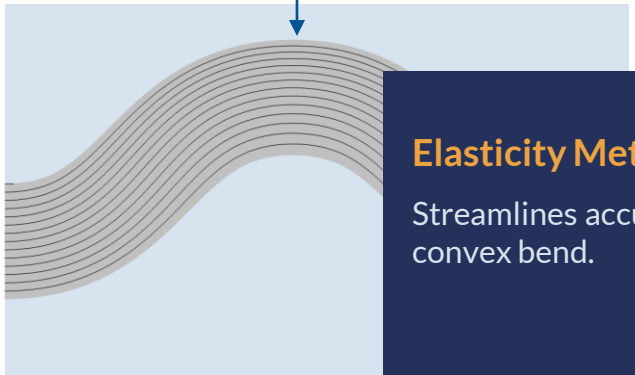
Adaptive Method

Evenly distributed streamlines.



Flow Method

Streamlines accumulate at convex bend.

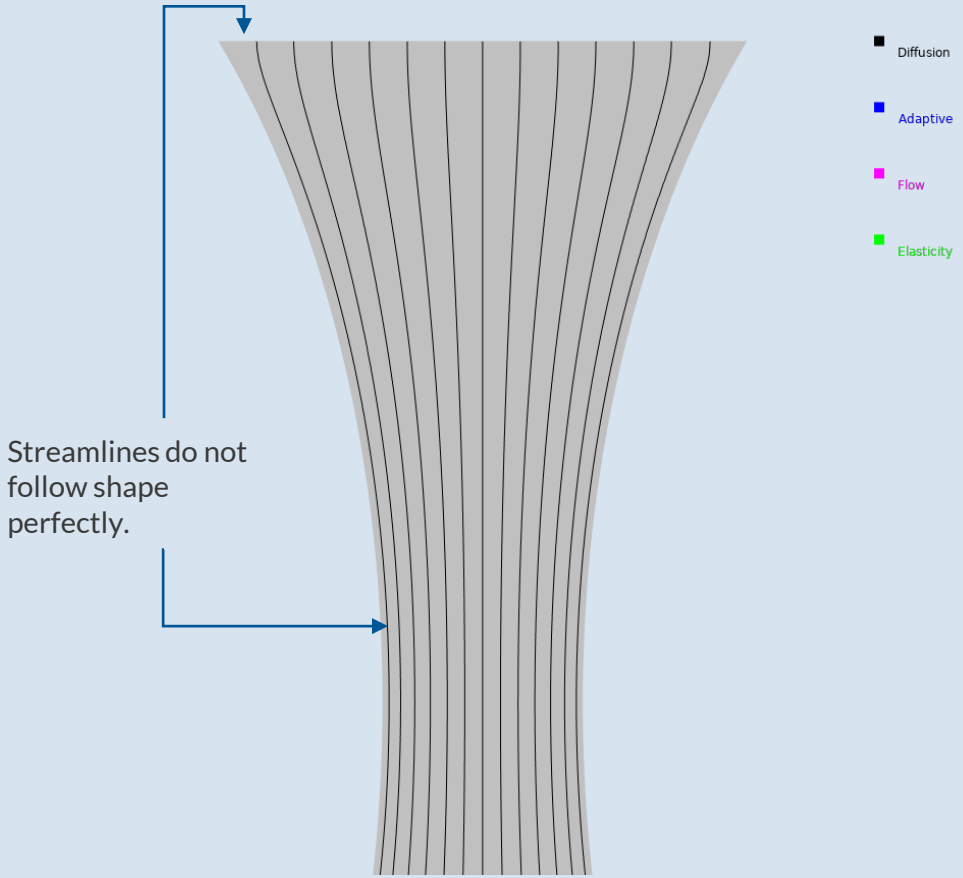


Elasticity Method

Streamlines accumulate at convex bend.

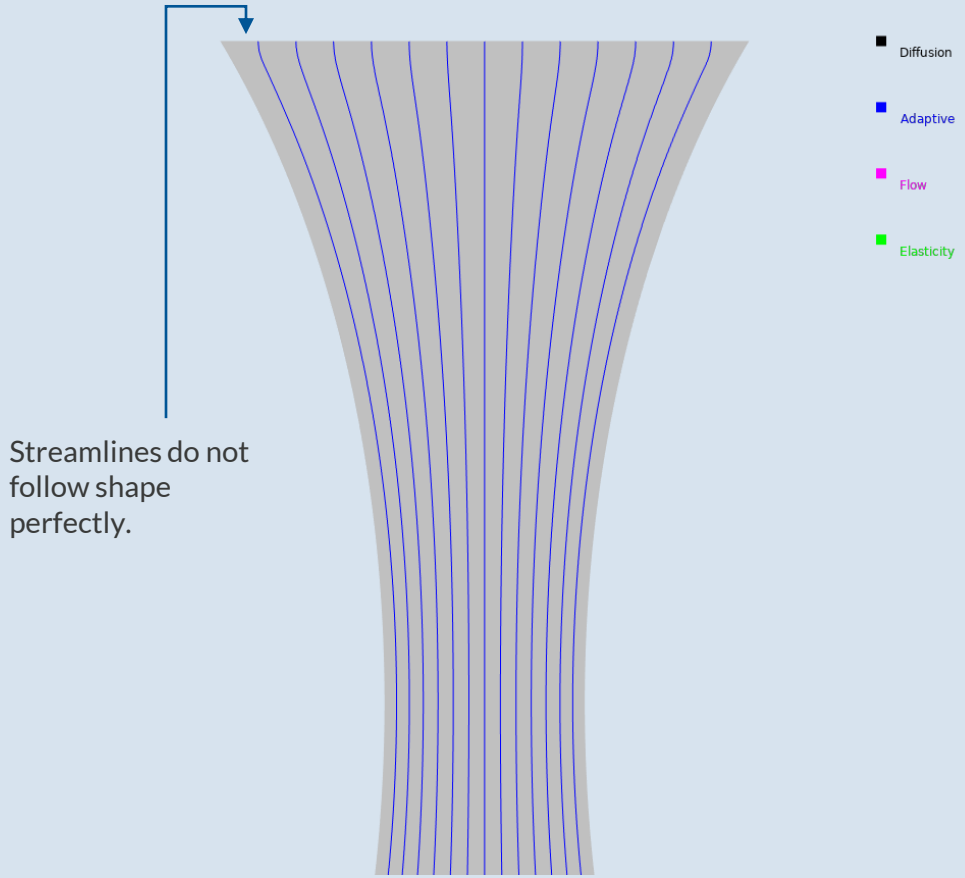
Variable Cross Section

Diffusion Method



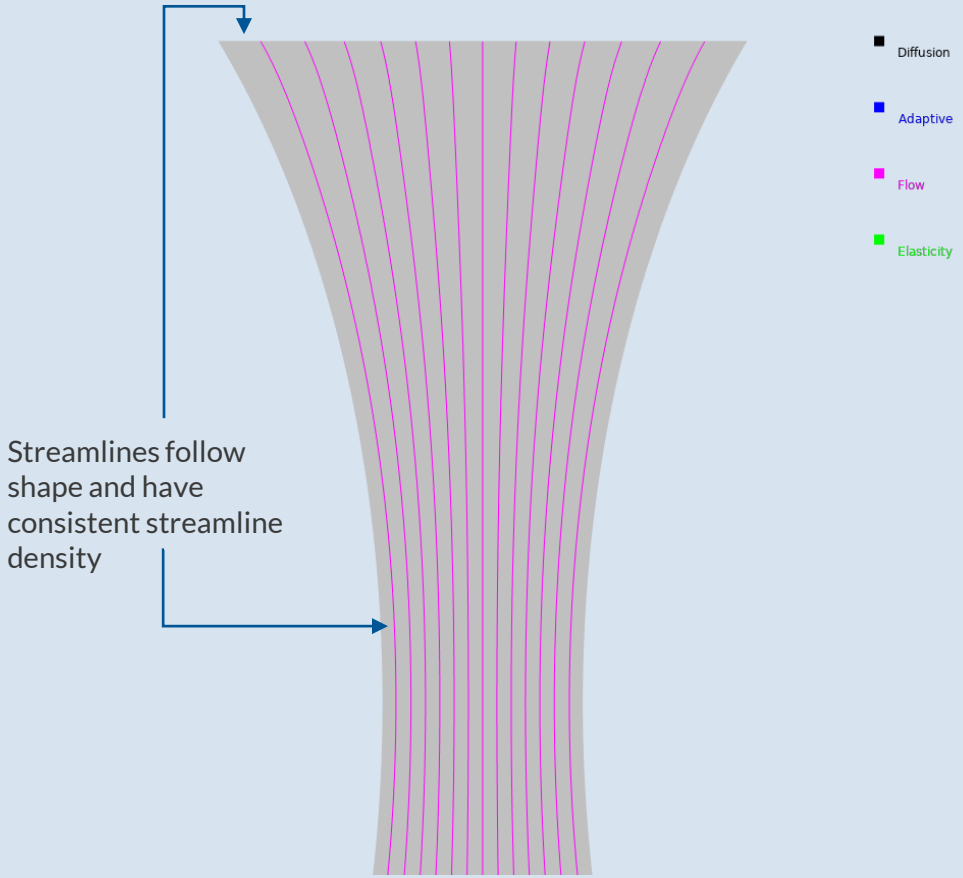
Variable Cross Section

Adaptive Method



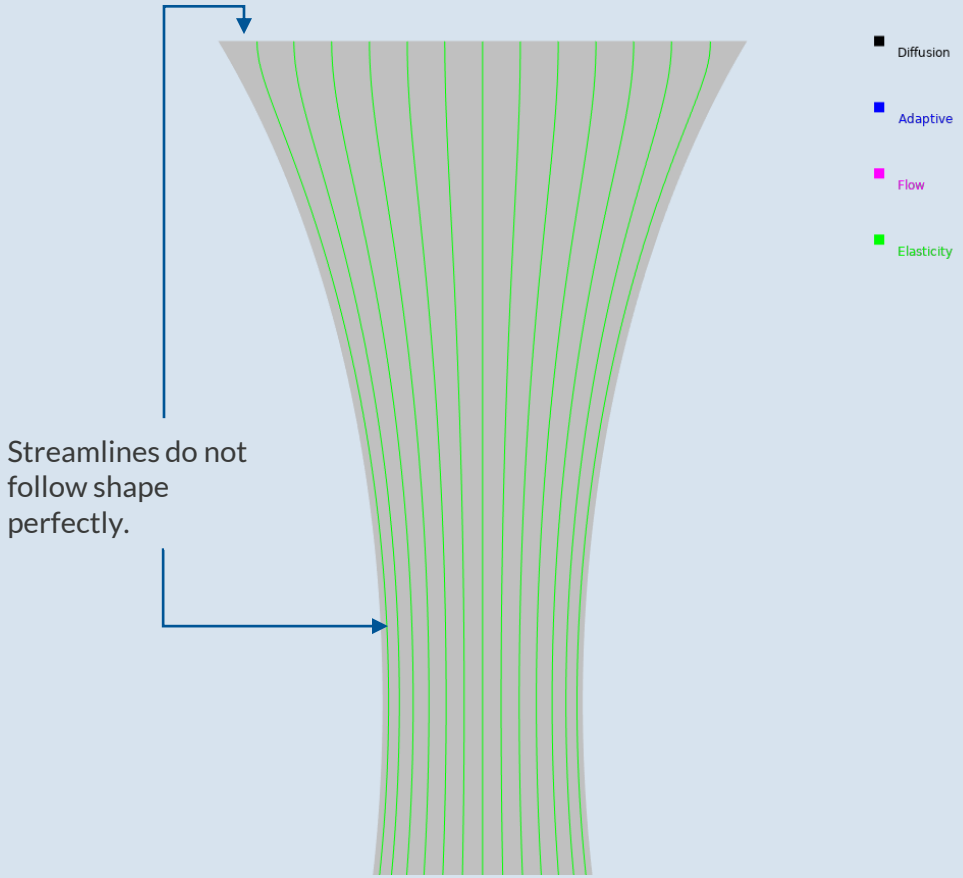
Variable Cross Section

Flow Method

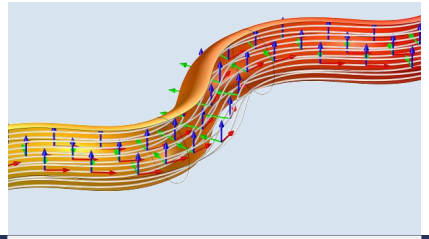


Variable Cross Section

Elasticity Method

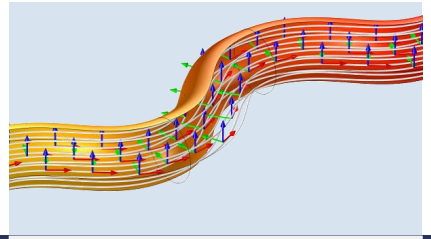


Summary



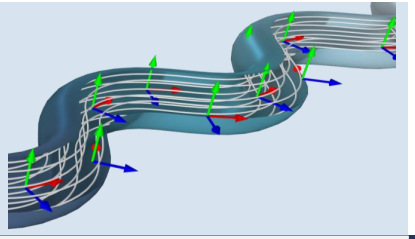
Diffusion

+ Simple and fast
- Not ideal for sharp bends and corners



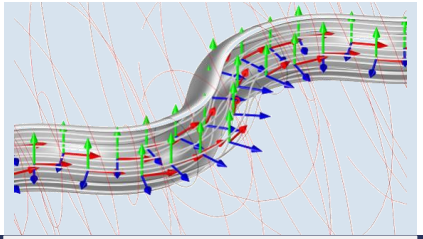
Adaptive

+ Simple and fast
- Not ideal for variable cross sections



Flow

+ Robust
+ Can handle most geometries
- High computational cost



Elasticity

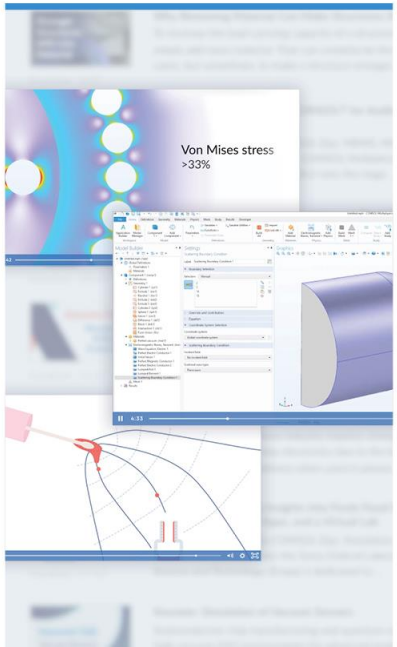
- Good geometry handling
- Not easy to solve for all cases, manual searching for eigenvalues

Further Resources for Inspiration

comsol.com

BLOG POSTS

VIDEOS



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MODELS & APPLICATIONS