

PENNSTATE





SolidWorks
WORLD 2010

PENNSTATE


Finite Element Analysis

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- Research Engineer
- Professor of Continuing Education
- Happy Valley SWUG, Leader
- CSWP

6

On-the-fly equation creation and editing



EDSGN 496A: **SolidWorks** Fundamentals

SKETCH: The Design Environment

Introduction, Objectives, and Goals

User Interface

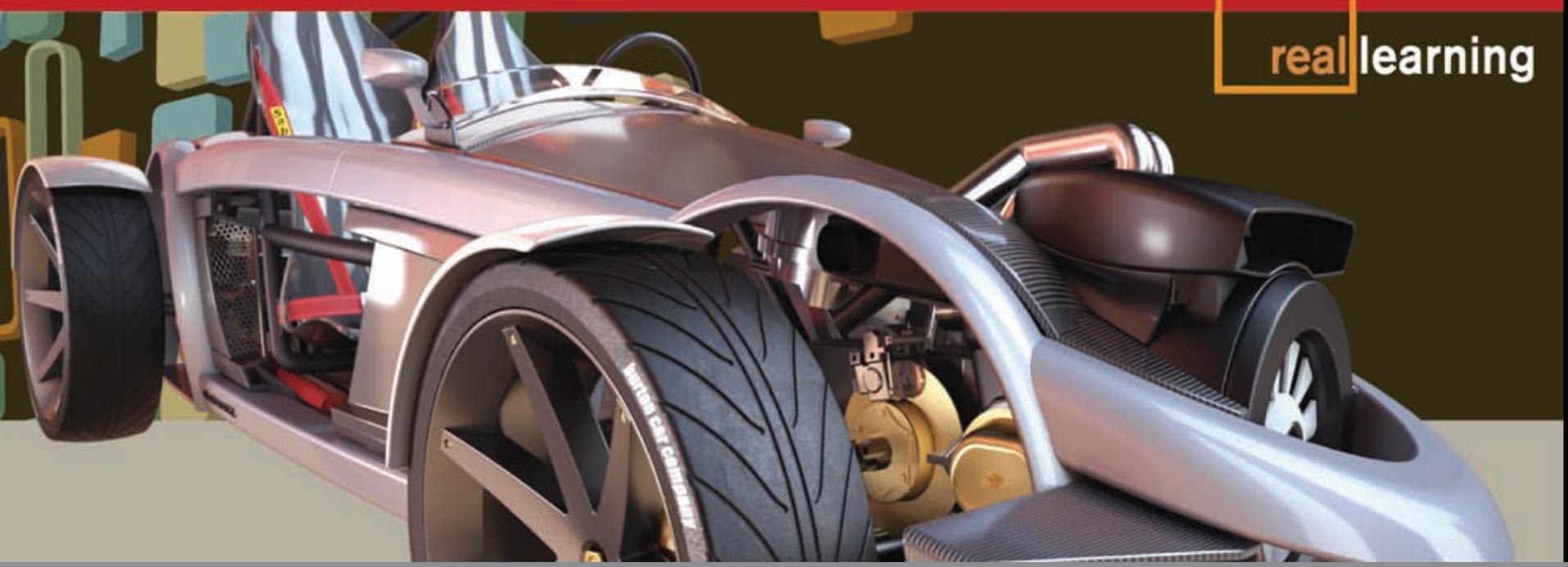
Associative Design

Design Intent & Constraints

CommandManager: Sketch & Features

Extruded Base

Basic Strategy



Mission Statement

Students should be proficient in communicating and analyzing designs as 3-D models.



Certificate of Achievement



85%



we **congratulate you** on your achievement

Randall Bock

has completed the requirements for:

Certified SolidWorks Associate

A handwritten signature in black ink on a yellow background.

Jeff Ray | CEO, Dassault Systèmes SolidWorks Corporation

Certificate ID: C-9RPRCJTJMY

HAPPY VALLEY
SolidWorks
USER GROUP

PENNSTATE
 THE SCHOOL OF ENGINEERING
DESIGN, TECHNOLOGY, AND
PROFESSIONAL PROGRAMS

Home

Next Meeting

Previous Events

CSWA & CSWP Members

EDSGN 496A

Local Information

Sponsors

Contact Us

Happy Valley SolidWorks User Group

Our Mission:



- The HVSUG is a network of academic and industrial resources dedicated to advancing the 3D CAD educational experience.
- Group meetings feature technical presentations in engineering design and analysis using SolidWorks.

Pedagogy

- Instructive theory
- Trainee teachers learn their subject and also the pedagogy appropriate for teaching that subject.

Andragogy

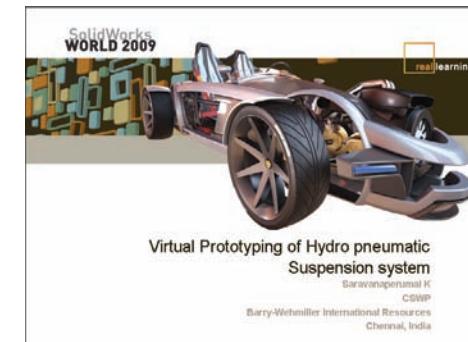
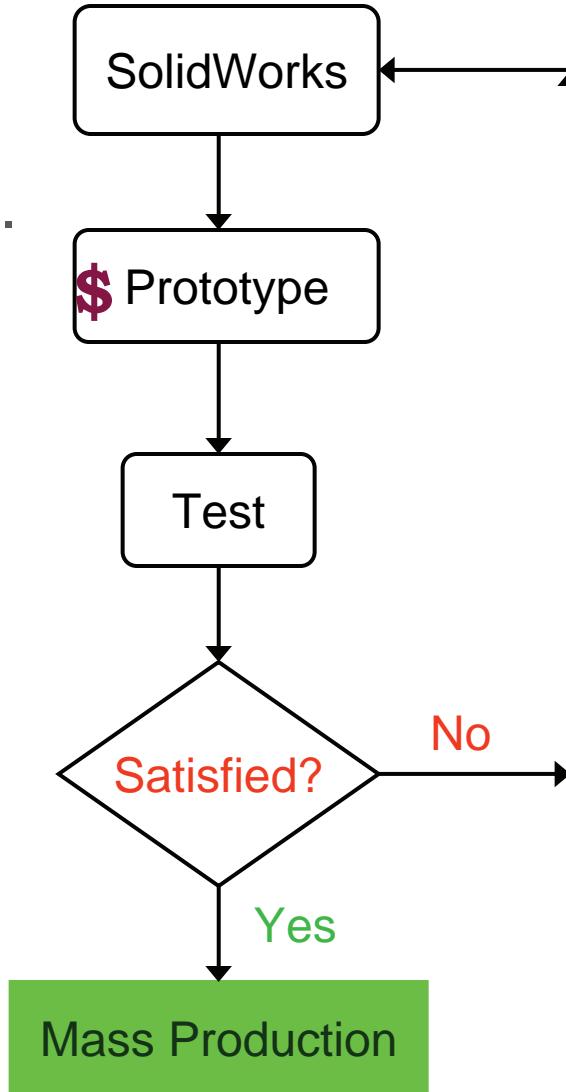
- The art and science of teaching adults.

Here's the Plan

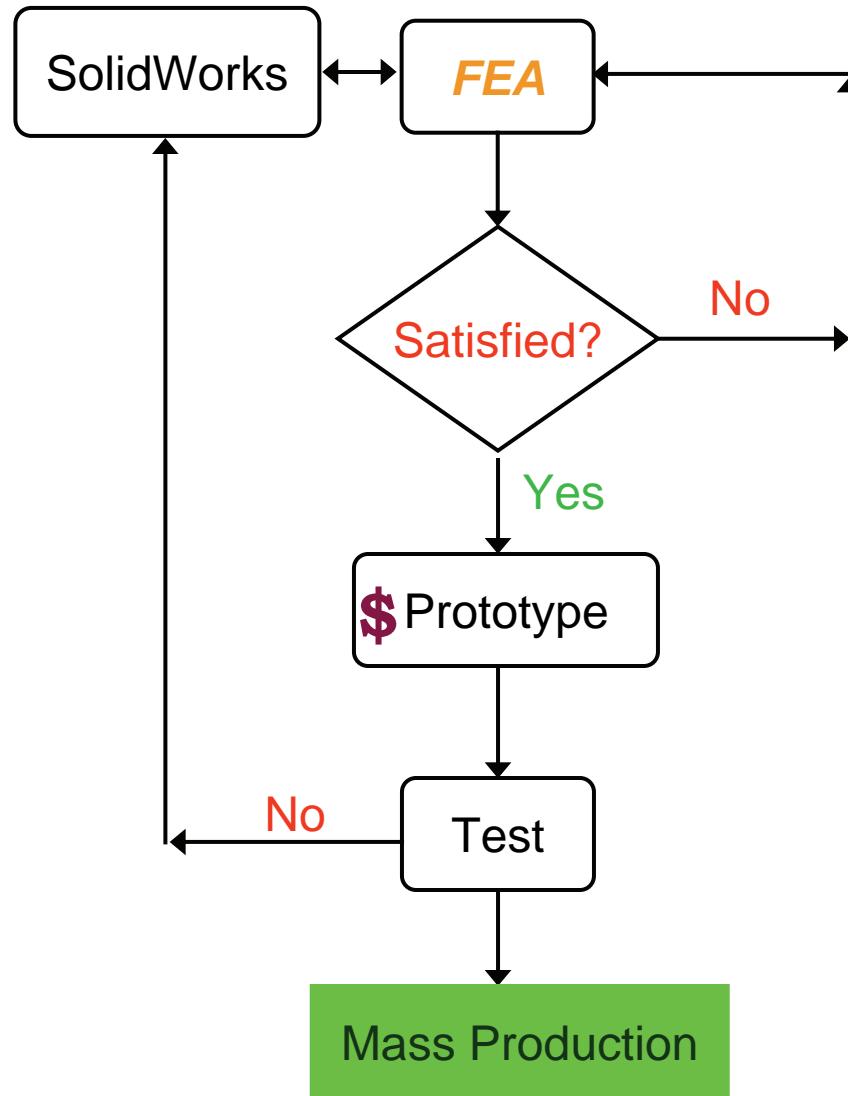
- **SolidWorks Simulation**
 - The Design Cycle
 - Finite Element Method
 - SolidWorks Simulation
 - Defining a Simulation Study
 - Controlling the Mesh
 - Accessing the Results
 - Identifying Singularities
 - Instructional Examples
 - Tips and Tricks

A Traditional Design Cycle

- Build a 3D model.
- Manufacture prototype.
- Test the prototype.
- Analyze results
 - modify the model
 - build a new prototype
 - test it again
 - repeat



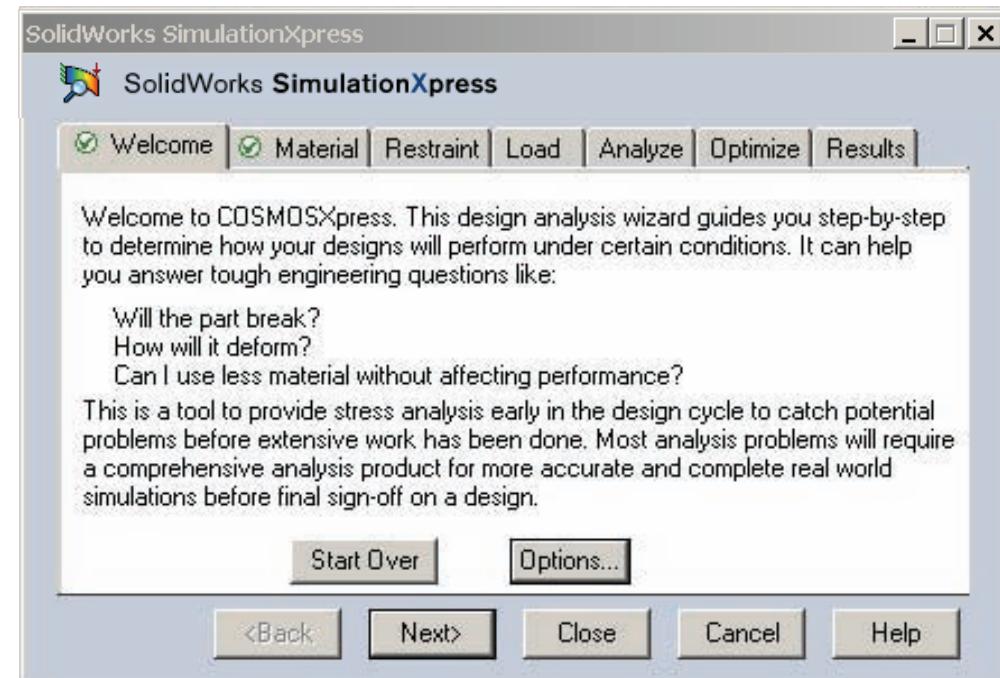
FEA Integrated Design Cycle



SimulationXpress

- ## Limitations

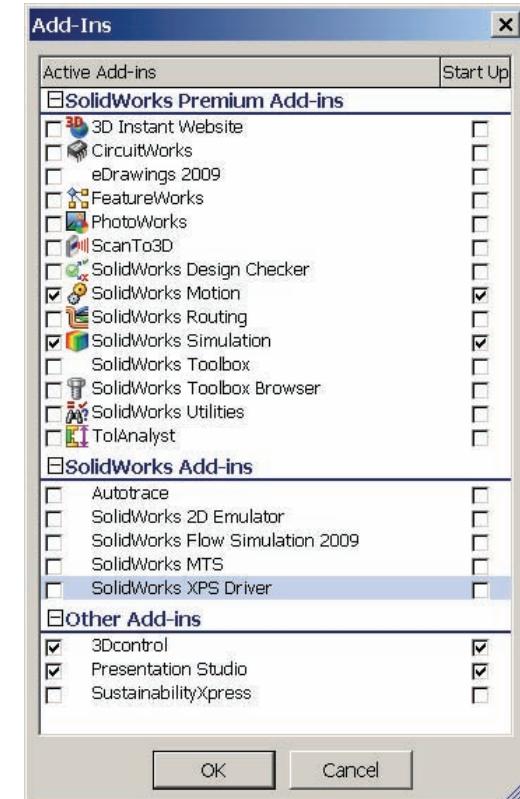
1. PARTs (one solid body)
2. Static analysis only (stress)
3. Optimize one variable
4. Isotropic materials
5. Uniform loads
6. Fixed restraints



SolidWorks Simulation

- **Advantages**

- Parts & Assemblies
- Non-linear, thermal, buckling, frequency, drop test, optimization, fatigue
- Isotropic & orthotropic materials
- Uniform & non-uniform loads
- Multiple restraints
- More...



SolidWorks Simulation 2010

Simulation Premium

Simulation Professional

Static*



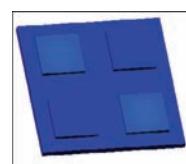
Frequency



Buckling



Thermal



Drop Test



Motion*



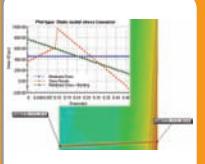
Fatigue



Optimization



Pressure Vessel



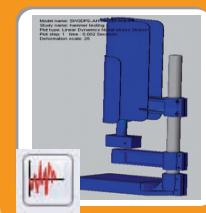
Event-based Motion



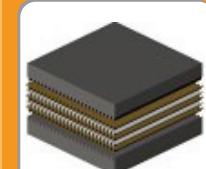
Nonlinear



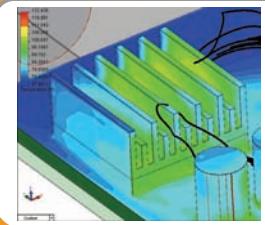
Linear Dynamics



Composites



Flow Simulation



Sustain-ability



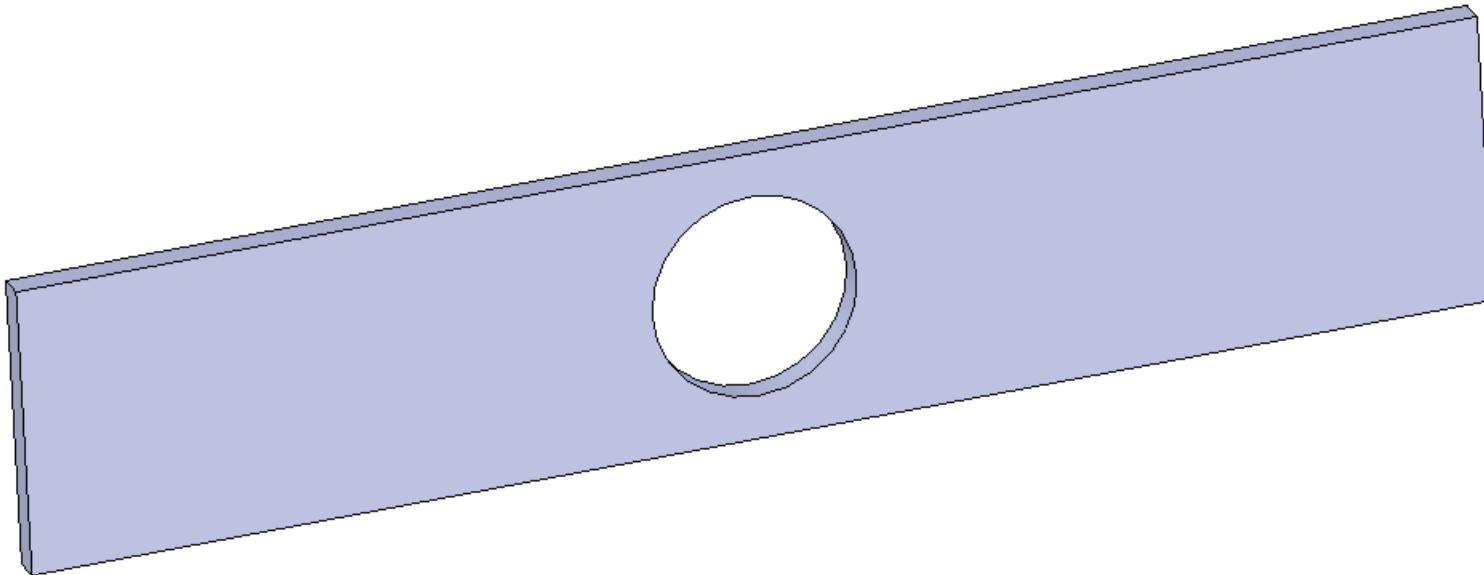
*Included with SolidWorks Premium

FEA Fundamentals

- Define and discretize the domain
- Specify approximating function and B.C.
- Create and converge system of equations
- Resolve for quantities of interest

FEA Fundamentals

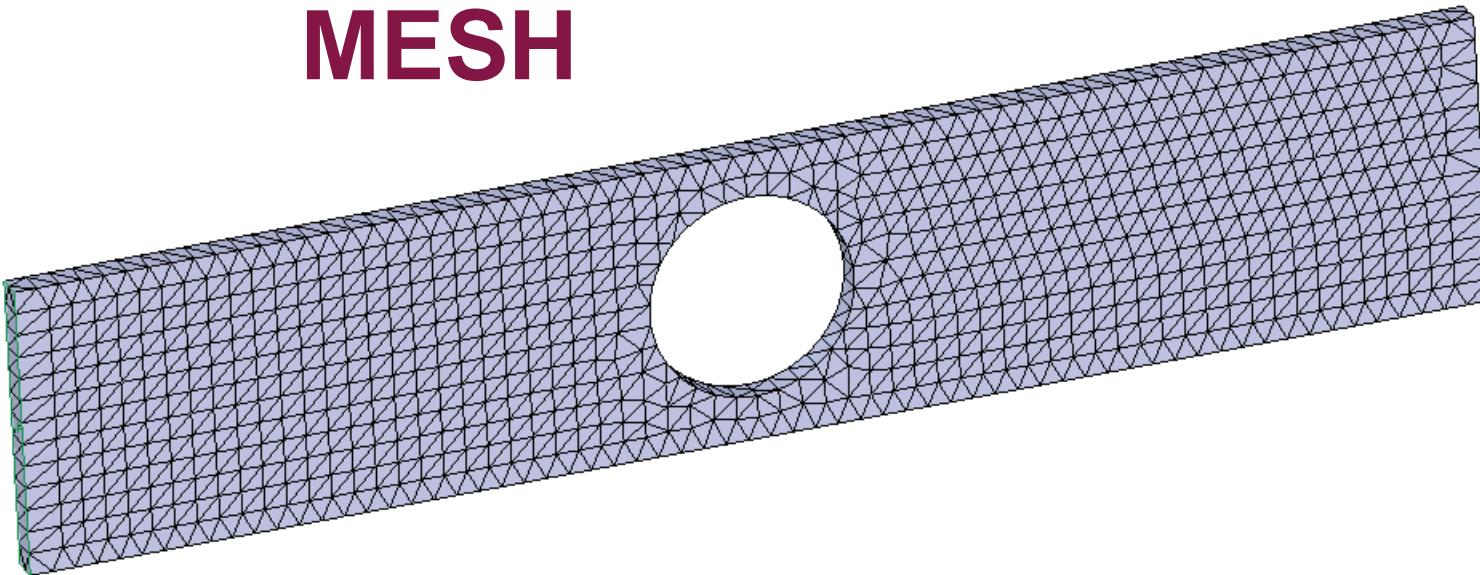
- Define the domain



FEA Fundamentals

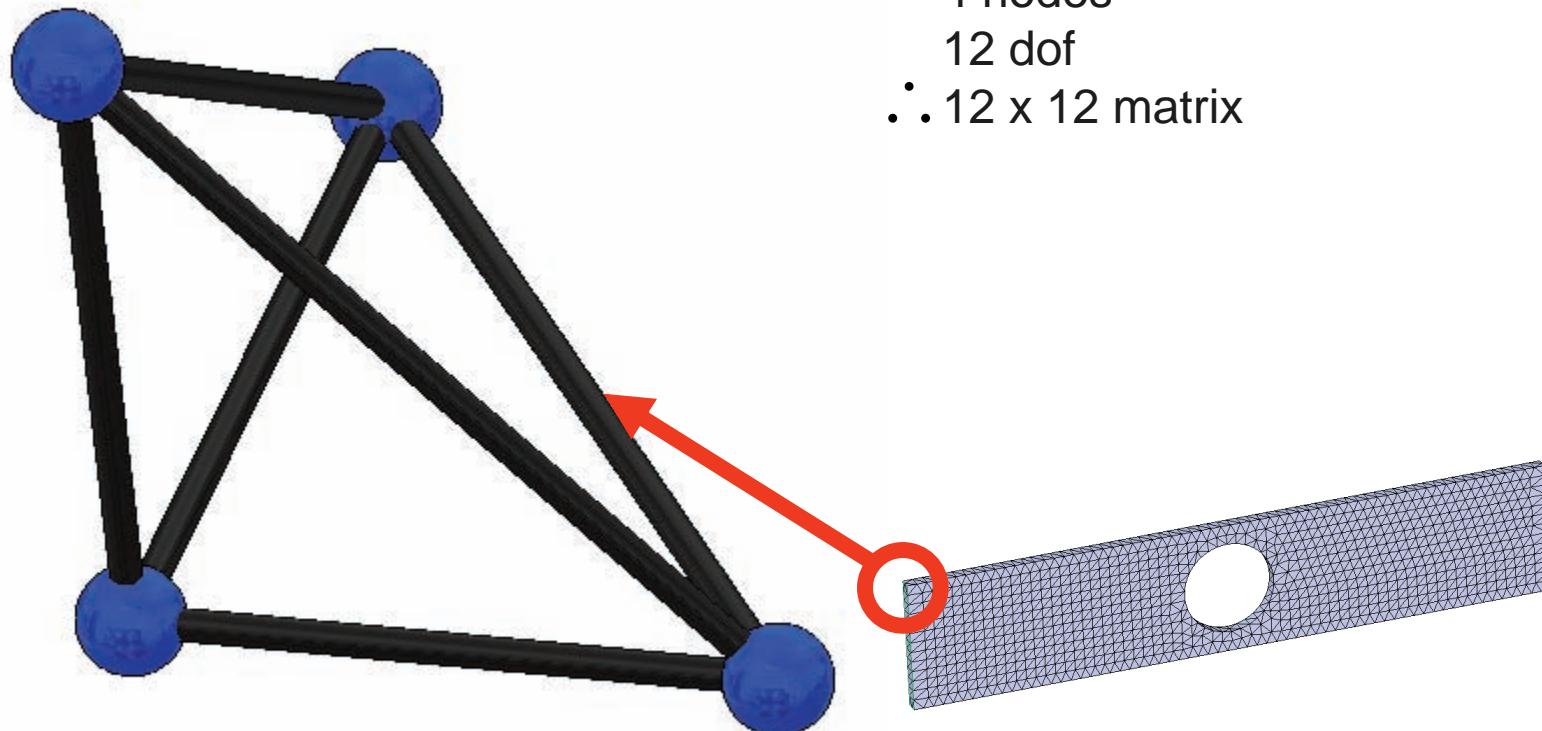
- Discretize the domain

MESH



FEA Fundamentals

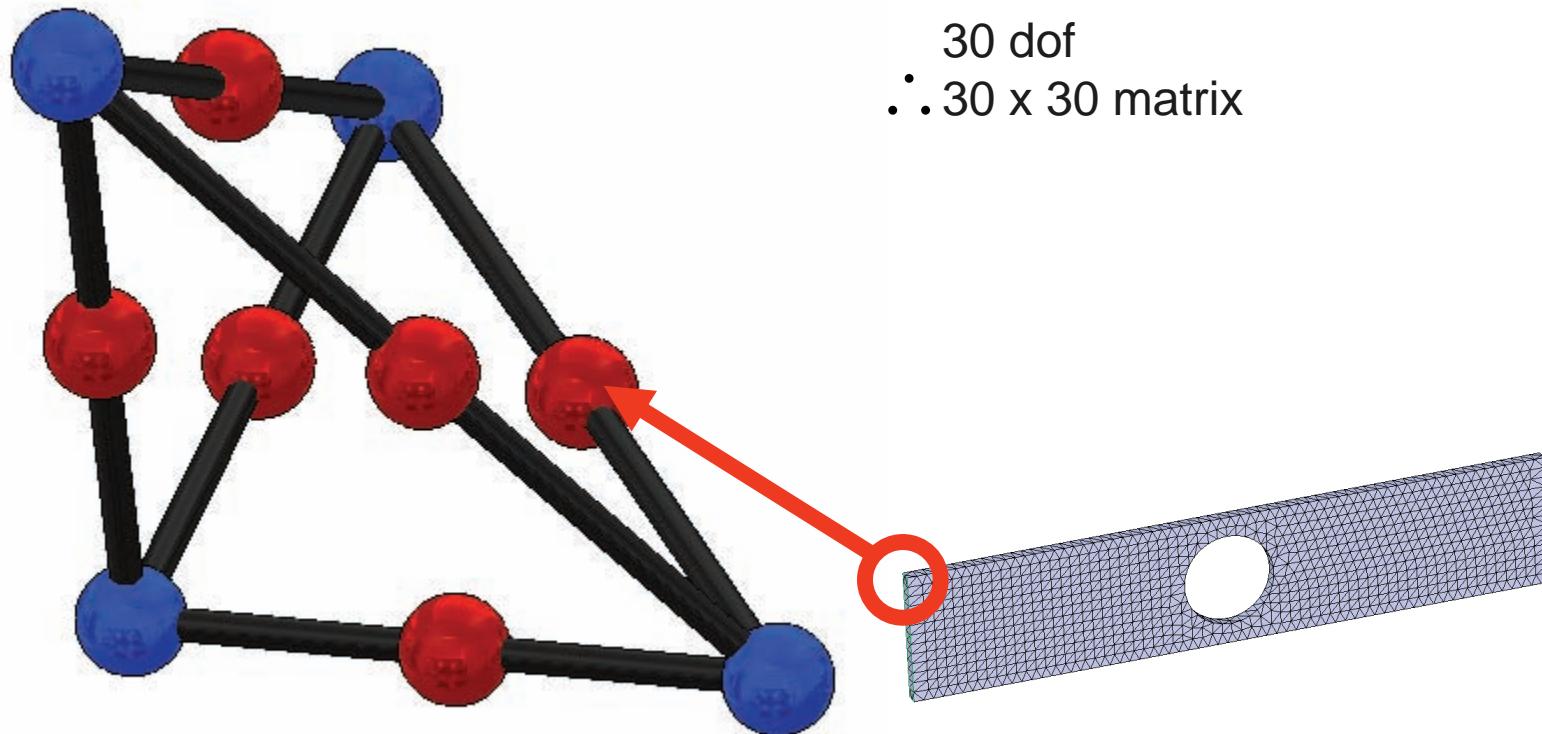
- Discretize using tetrahedrons: 1st order (linear)
 - 1 element
 - 4 nodes



First Order Structural Tetrahedron Element:
4 nodes
12 dof
 $\therefore 12 \times 12$ matrix

FEA Fundamentals

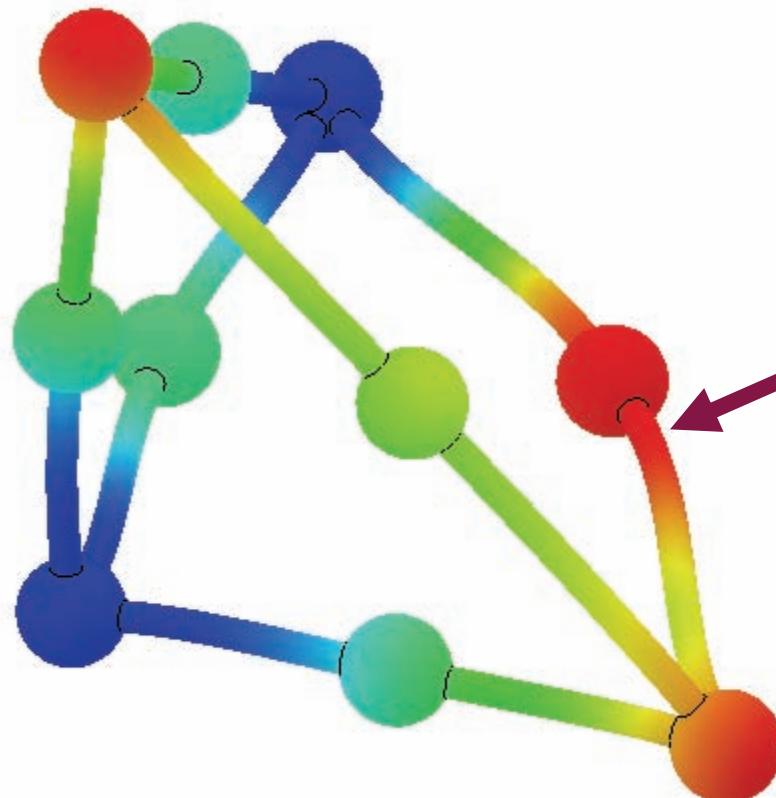
- Discretize using tetrahedrons: 2nd order (quadratic)
 - 1 element
 - **10** nodes



Second Order Structural Tetrahedron Element:
10 nodes
30 dof
 $\therefore 30 \times 30$ matrix

FEA Fundamentals

- Discretize using tetrahedrons: 2nd order
 - 1 element
 - **10** nodes

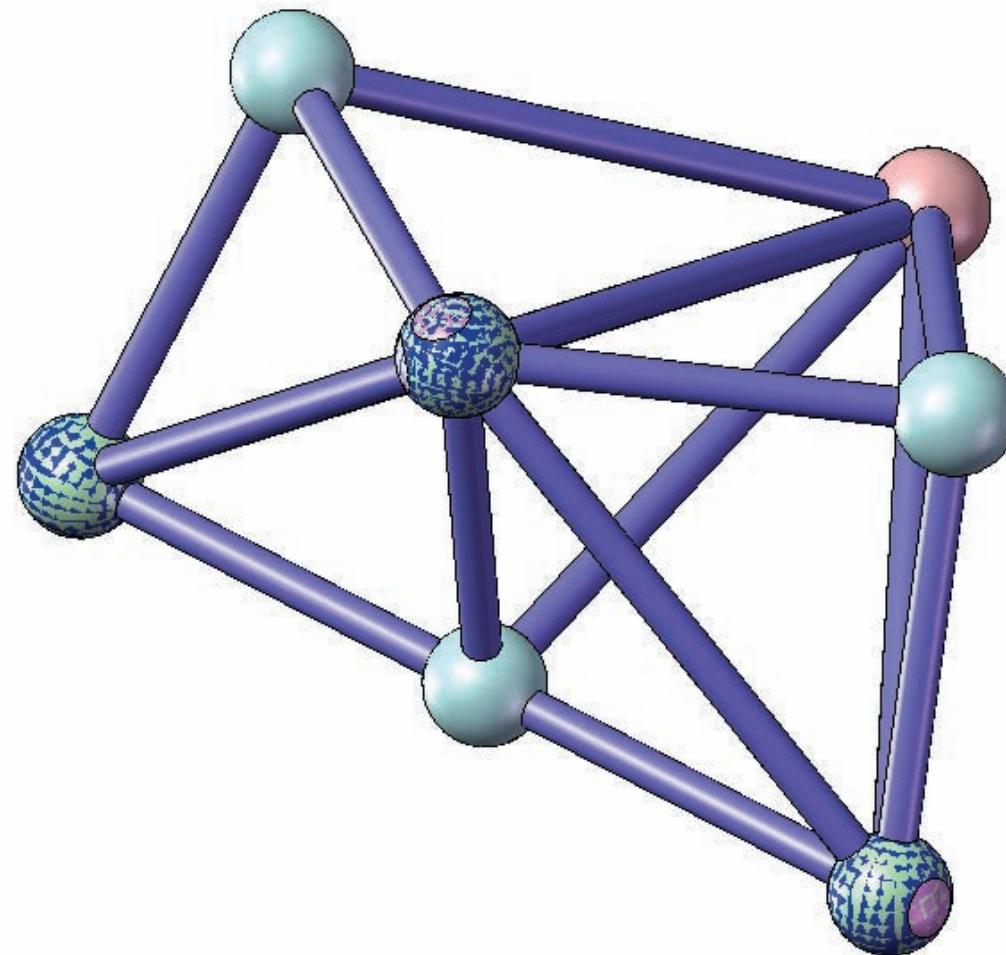


Second Order Structural Tetrahedron Element:
10 nodes
30 dof
 $\therefore 30 \times 30$ matrix

Curved

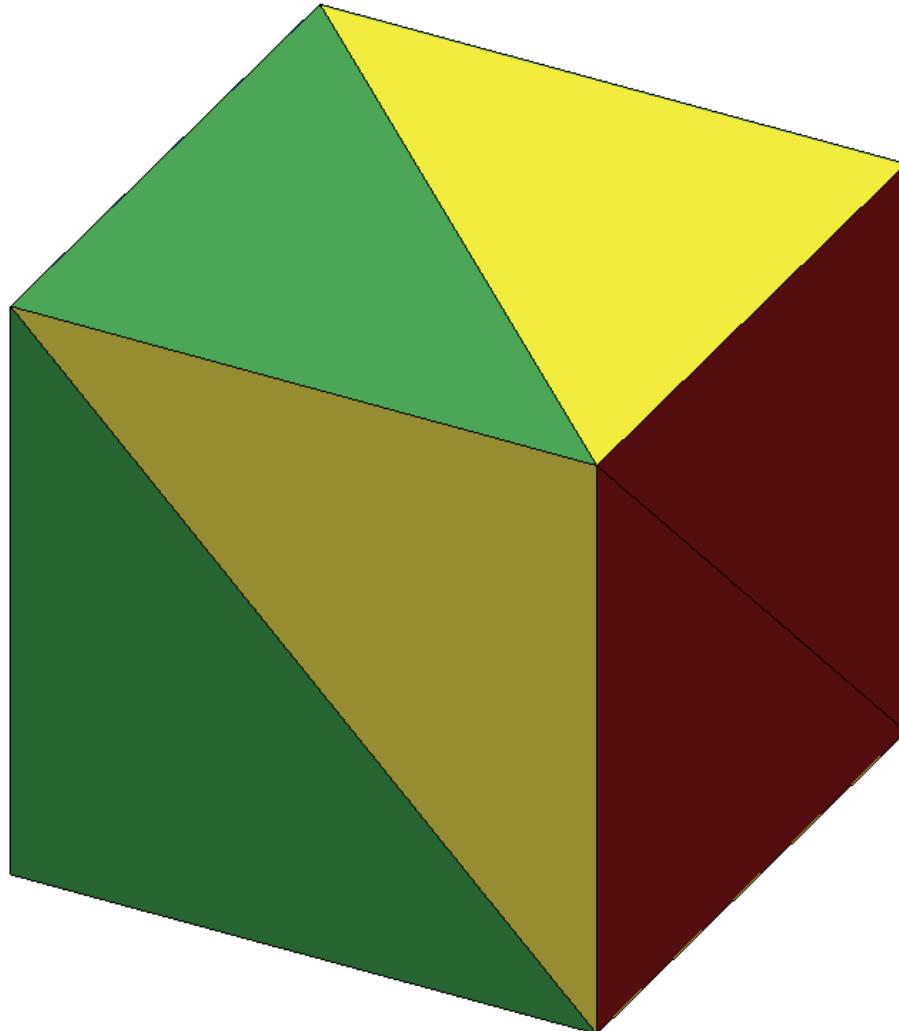
FEA Fundamentals

- Neighboring elements share nodes
 - 4 element
 - 7 nodes
 - DOF ?



FEA Fundamentals

- Cube
 - 12 element
 - 9 nodes
 - DOF ?



FEA Fundamentals

- Specify approximating function

Big Math Warning

And also an...

AVATAR Warning

A close-up, high-angle shot of Jake Sully's face as an Avatár. He has blue skin, yellow eyes, and a brown Na'vi headdress with feathers. His expression is serious and intense.

AVATAR

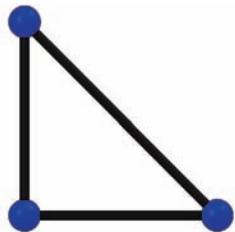
DECEMBER 18 2009 WORLDWIDE

FEA Fundamentals

- Specify approximating function

FEA Fundamentals

- Specify AVATAR function (2D Triangle, linear)

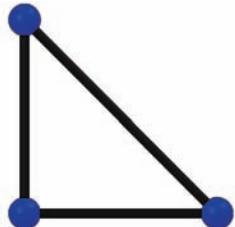


$$u^{(e)}(x, y) = \alpha_o + \alpha_1 x + \alpha_2 y$$

EACH ELEMENT

FEA Fundamentals

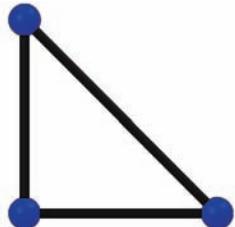
- Specify approximating function (new node values)



$$\underline{u^{(e)}(x, y) = \alpha_o + \alpha_1 x + \alpha_2 y}$$

FEA Fundamentals

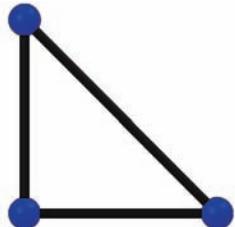
- Specify approximating function (unknown coefficients)



$$u^{(e)}(x, y) = \underline{\alpha}_0 + \underline{\alpha}_1 x + \underline{\alpha}_2 y$$

FEA Fundamentals

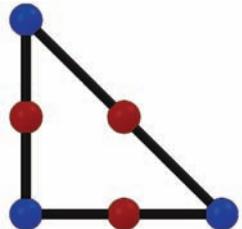
- Specify approximating function (current node values)



$$u^{(e)}(x, y) = \alpha_0 + \alpha_1 \underline{x} + \alpha_2 \underline{y}$$

FEA Fundamentals

- Specify AVATAR function (2D Triangle, quadratic)

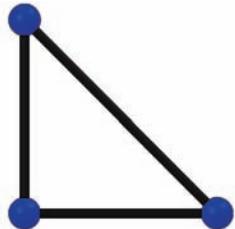


$$u(x, y) = \alpha_o + \alpha_1x + \alpha_2y + \alpha_3x^2 + \alpha_4xy + \alpha_5y^2$$

$$v(x, y) = \beta_o + \beta_1x + \beta_2y + \beta_3x^2 + \beta_4xy + \beta_5y^2$$

FEA Fundamentals

- Specify approximating function

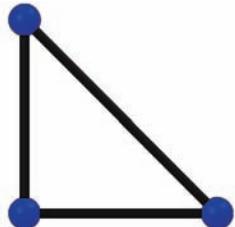


$$u(x, y) = \alpha_o + \alpha_1 x + \alpha_2 y$$

$$v(x, y) = \beta_o + \beta_1 x + \beta_2 y$$

FEA Fundamentals

- Specify approximating function



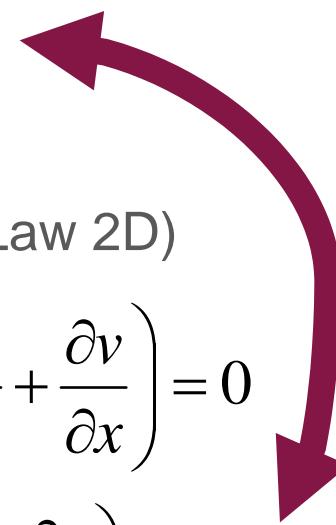
$$u(x, y) = \alpha_0 + \alpha_1 x + \alpha_2 y$$

$$v(x, y) = \beta_0 + \beta_1 x + \beta_2 y$$

- Equilibrium equations (Hook's Law 2D)

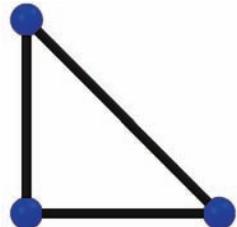
$$+\frac{E}{1-\nu^2}\frac{\partial}{\partial x}\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)+G\frac{\partial}{\partial y}\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)=0$$

$$+G\frac{\partial}{\partial x}\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)+\frac{E}{1-\nu^2}\left(\nu\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)=0$$



FEA Fundamentals

- Specify approximating function



$$u(x, y) = \alpha_0 + \alpha_1 x + \alpha_2 y$$

$$v(x, y) = \beta_0 + \beta_1 x + \beta_2 y$$

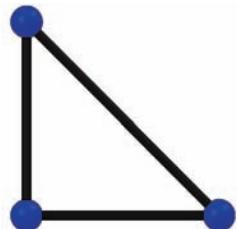
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FEA Fundamentals

- Specify approximating function



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- Equilibrium equations (Hook's Law 2D)

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$$+G\frac{\partial}{\partial x}\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)+\frac{E}{1-\nu^2}\left(\nu\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)=0$$

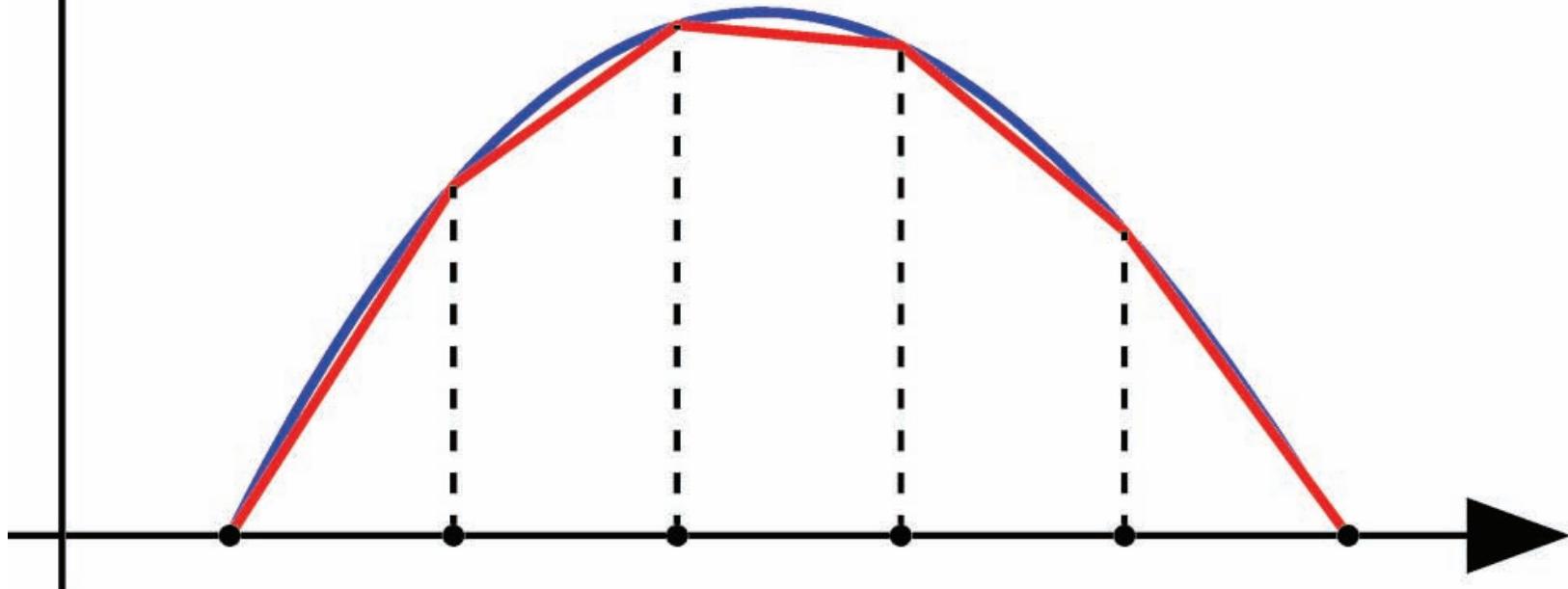
Moduli conversion

Sidebar

	(λ, G)	(E, G)	(K, λ)	(K, G)	(λ, ν)	(G, ν)	(E, ν)	(K, ν)	(K, E)	(M, G)
$K =$	$\lambda + \frac{2G}{3}$	$\frac{EG}{3(3G - E)}$			$\lambda \frac{1+\nu}{3\nu}$	$\frac{2G(1+\nu)}{3(1-2\nu)}$	$\frac{E}{3(1-2\nu)}$			$M - \frac{4G}{3}$
$E =$	$G \frac{3\lambda + 2G}{\lambda + G}$		$9K \frac{K-\lambda}{3K-\lambda}$	$\frac{9KG}{3K+G}$	$\frac{\lambda(1+\nu)(1-2\nu)}{\nu}$	$2G(1+\nu)$		$3K(1-2\nu)$		$G \frac{3M-4G}{M-G}$
$\lambda =$		$G \frac{E-2G}{3G-E}$		$K - \frac{2G}{3}$		$\frac{2G\nu}{1-2\nu}$	$\frac{E\nu}{(1+\nu)(1-2\nu)}$	$\frac{3K\nu}{1+\nu}$	$\frac{3K(3K-E)}{9K-E}$	$M - 2G$
$G =$			$3 \frac{K-\lambda}{2}$		$\lambda \frac{1-2\nu}{2\nu}$		$\frac{E}{2(1+\nu)}$	$3K \frac{1-2\nu}{2(1+\nu)}$	$\frac{3KE}{9K-E}$	
$\nu =$	$\frac{\lambda}{2(\lambda+G)}$	$\frac{E}{2G} - 1$	$\frac{\lambda}{3K-\lambda}$	$\frac{3K-2G}{2(3K+G)}$					$\frac{3K-E}{6K}$	$\frac{M-2G}{2M-2G}$
$M =$	$\lambda + 2G$	$G \frac{4G-E}{3G-E}$	$3K - 2\lambda$	$K + \frac{4G}{3}$	$\lambda \frac{1-\nu}{\nu}$	$G \frac{2-2\nu}{1-2\nu}$	$E \frac{1-\nu}{(1+\nu)(1-2\nu)}$	$3K \frac{1-\nu}{1+\nu}$	$3K \frac{3K+E}{9K-E}$	



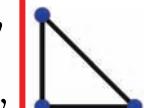
$$+\frac{E}{1-\nu^2}\frac{\partial}{\partial x}\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)+G\frac{\partial}{\partial y}\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)=0$$
$$+G\frac{\partial}{\partial x}\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)+\frac{E}{1-\nu^2}\left(\nu\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)=0$$



AVATAR

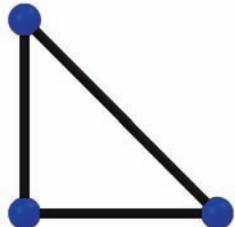
$$u(x, y) = \alpha_o + \alpha_1 x + \alpha_2 y$$

$$v(x, y) = \beta_o + \beta_1 x + \beta_2 y$$



FEA Fundamentals

- Specify approximating function



$$u(x, y) = \alpha_0 + \alpha_1 x + \alpha_2 y$$

$$v(x, y) = \beta_0 + \beta_1 x + \beta_2 y$$

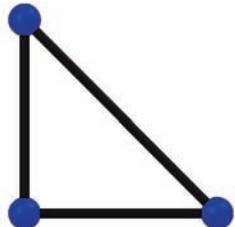
- Equilibrium equations (Hook's Law 2D)

$$+\frac{E}{1-\nu^2}\frac{\partial}{\partial x}\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)+G\frac{\partial}{\partial y}\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)=0$$

$$+G\frac{\partial}{\partial x}\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)+\frac{E}{1-\nu^2}\left(\nu\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)=0$$

FEA Fundamentals

- Specify approximating function



$$u(x, y) = \alpha_0 + \alpha_1 x + \alpha_2 y$$

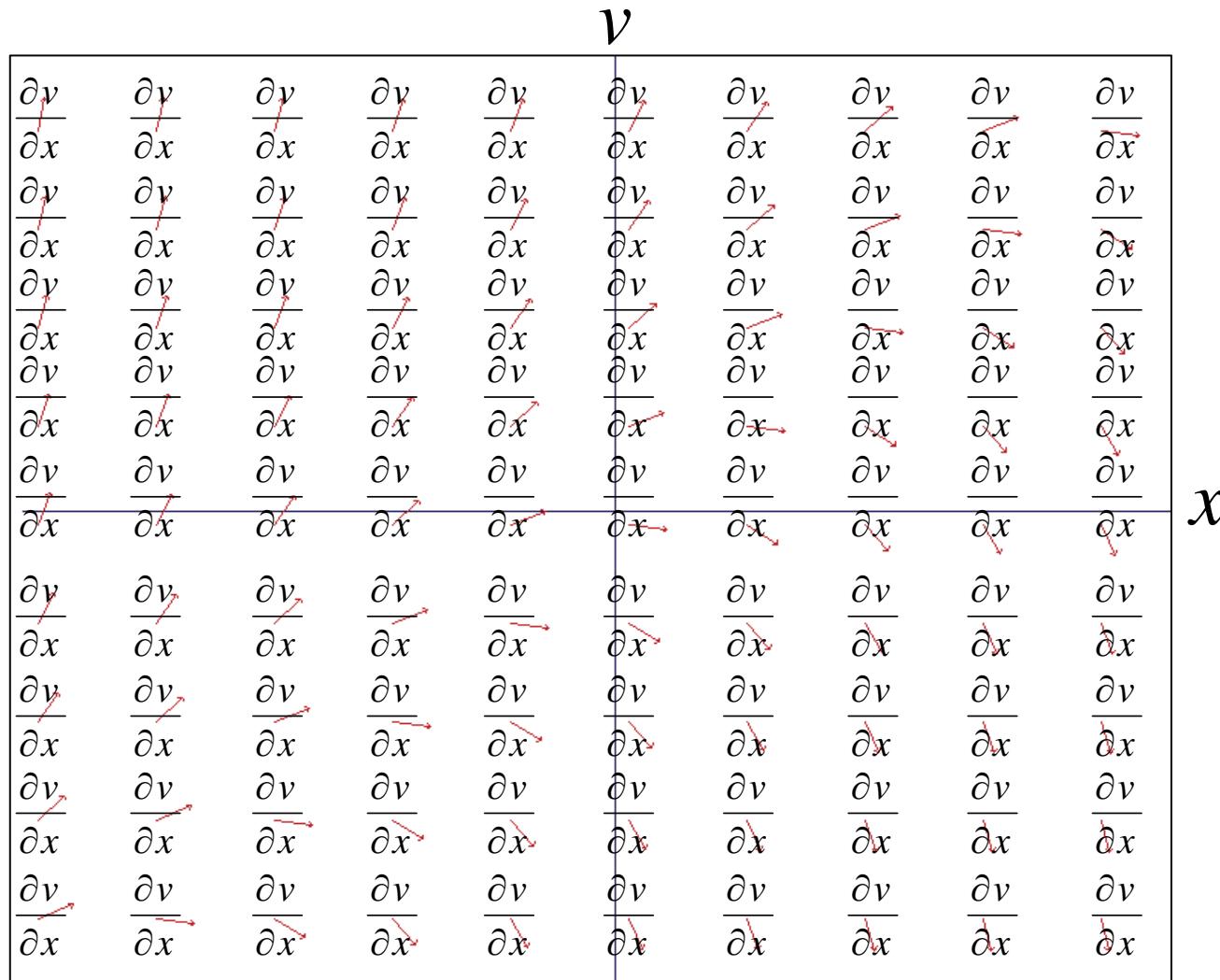
$$v(x, y) = \beta_0 + \beta_1 x + \beta_2 y$$

- Equilibrium equations (Hook's Law 2D)

$$+\frac{E}{1-\nu^2}\frac{\partial}{\partial x}\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)+G\frac{\partial}{\partial y}\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)=0$$

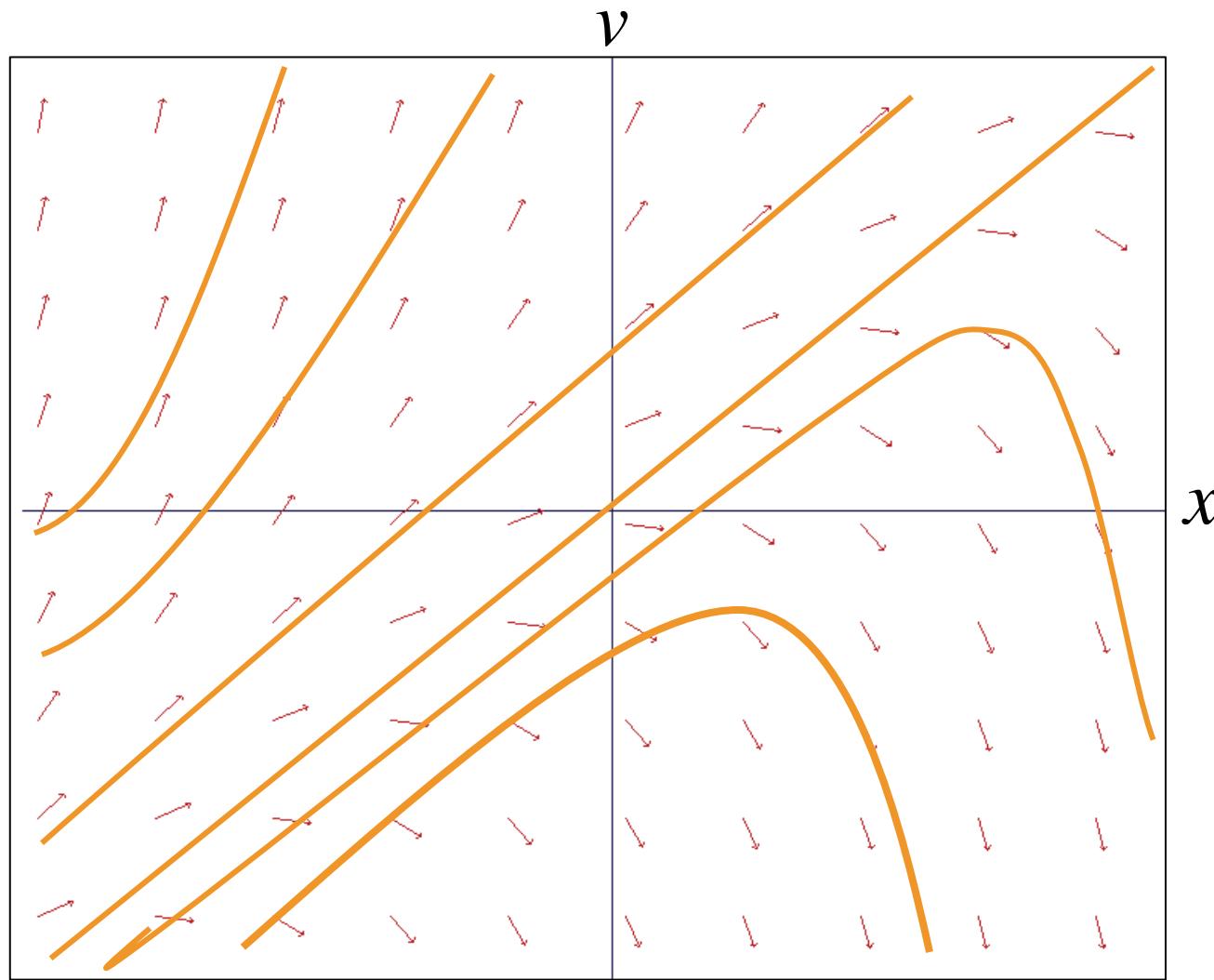
$$+G\frac{\partial}{\partial x}\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)+\frac{E}{1-\nu^2}\left(\nu\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)=0$$

Slope Field: $\frac{\partial v}{\partial x} = v - x$

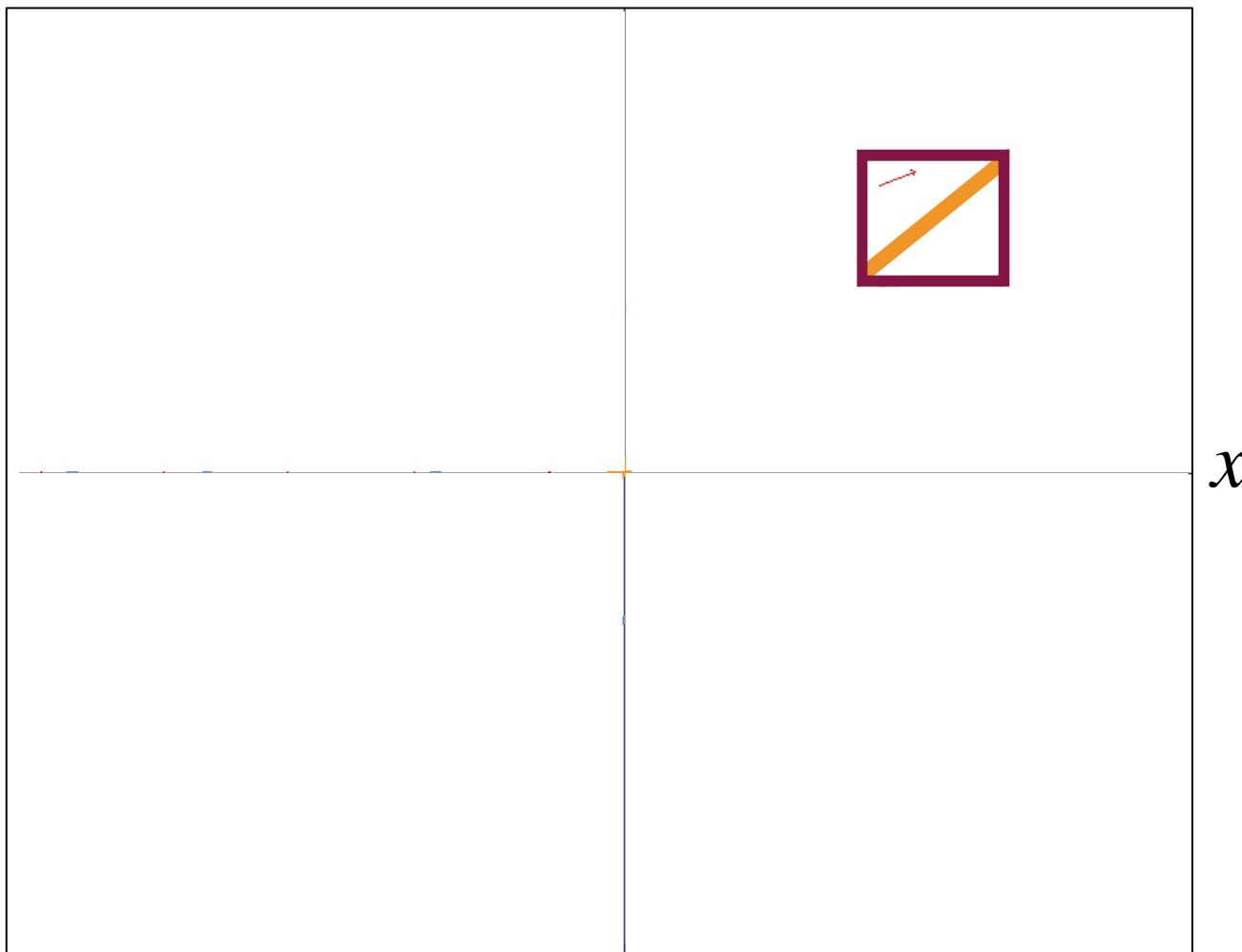


Solutions:

$$\frac{\partial v}{\partial x} = v - x$$

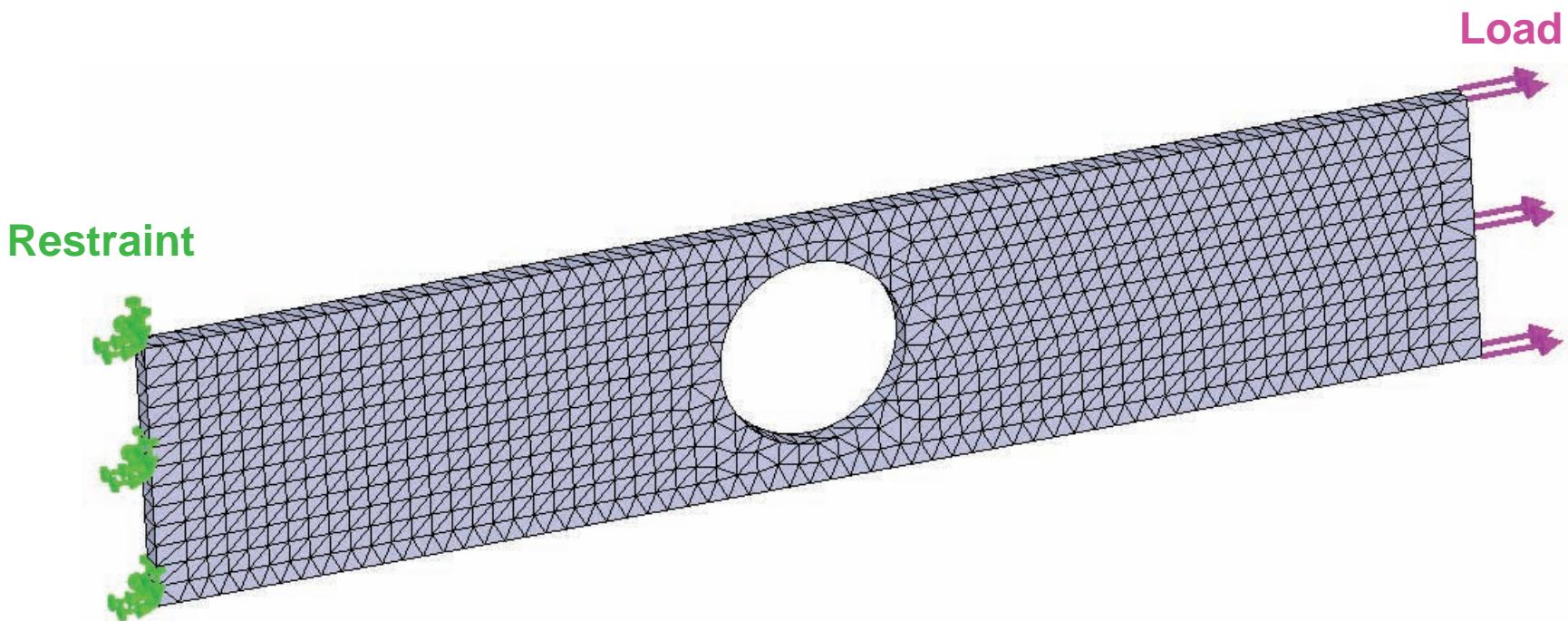


Solutions: $\frac{\partial v}{\partial x} = v - x$



FEA Fundamentals

- Specify the boundary conditions



FEA Fundamentals (basic strategy)

- Create and converge system of equations

- 1) Plug initial mesh geometry into

$$u(x, y) = \alpha_o + \alpha_1 x + \alpha_2 y$$

$$v(x, y) = \beta_o + \beta_1 x + \beta_2 y$$



- 2) Plug new node values from 1) into

$$+ \frac{E}{1-\nu^2} \frac{\partial}{\partial x} \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \right) + G \frac{\partial}{\partial y} \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right) = 0$$

$$+ G \frac{\partial}{\partial x} \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right) + \frac{E}{1-\nu^2} \left(\nu \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \right) = 0$$



- 3) Subtract 1) from 2)



- 4) Difference 3) drives next iteration

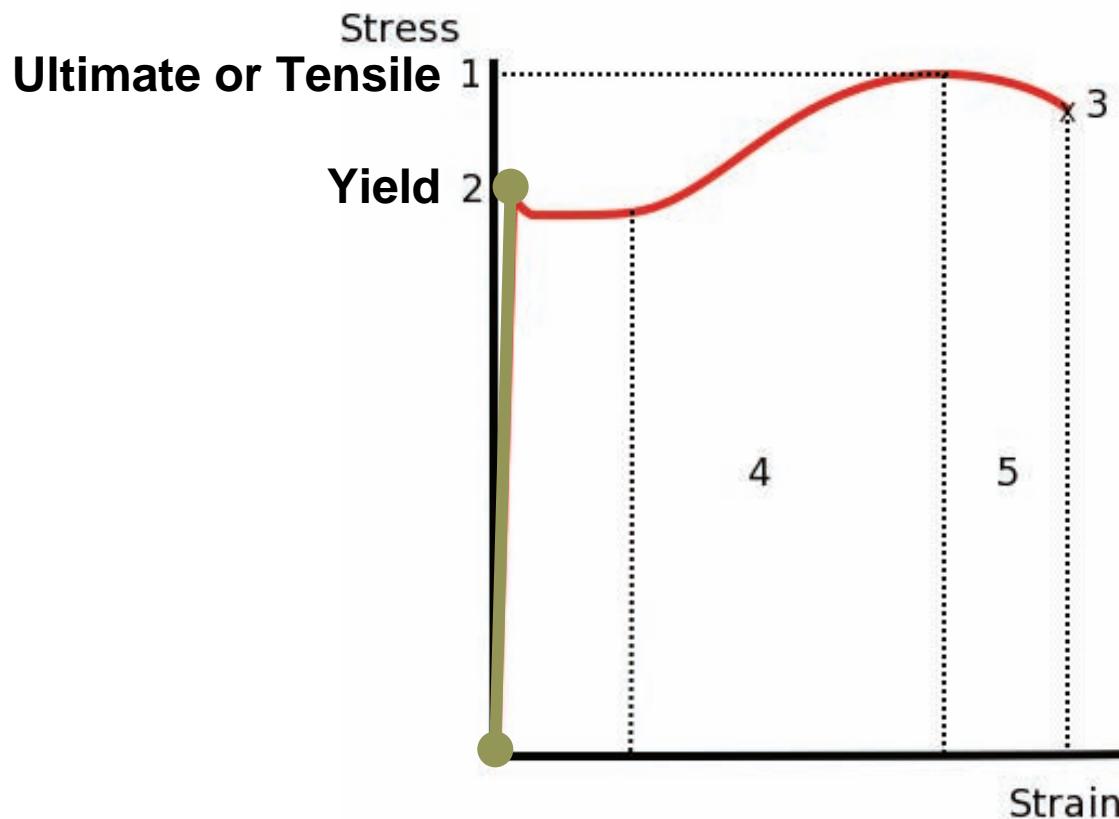
FEA Fundamentals

- Resolve for other quantities of interest
 - Strain (ϵ)
 - Stress (σ)
 - von Mises Stress: $\sigma_{eq} = \sqrt{0.5[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2]}$

Linear elastic stress analysis

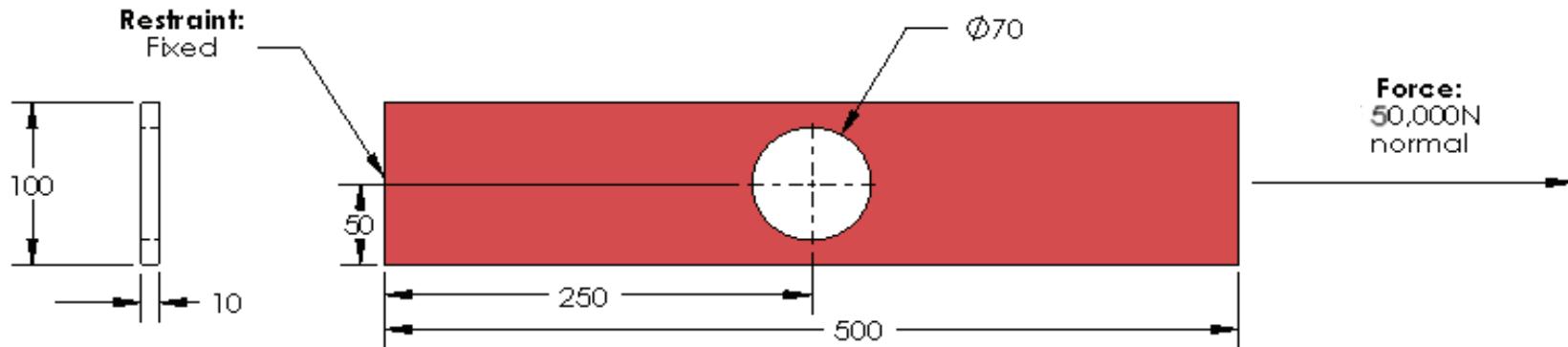
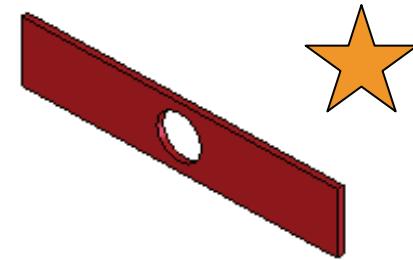


- Small displacements with constant b.c.
- Material properties constant (ductile)



Defining a Study (fea fundamentals)

1. Define the type of analysis. (specify approx. function)
2. Create a study.
3. Define material for each component.
4. Define Connections. (b.c.: component-component)
5. Define Fixtures. (b.c.: reduce model DOF)
6. Define External Loads. (b.c.: force, pressure, torque)
7. Define the Mesh. (discretize the domain)
8. Run the analysis. (solve linear system)
9. View Results.
10. Interpret results.



Material: Alloy Steel Units: MMGS

TITLE:		
Example 13.1, SWS Rectangular Plate with Hole		
SIZE	Course:	REV
A	EDSGN 496A	
SCALE: 1:5 RGB		SHEET 1 OF 1

Analytical vs. FEA (node)

$$\sigma_{\max} = K_n \times \sigma_n$$

Stress concentration factor, (flat plate, circular hole, D/W>0.65):

$$K_n = 2 + \left(1 - \frac{D}{W}\right)^3$$

Normal stress, at hole cross section:

$$\sigma_n = \frac{P}{(W - D) \times T}$$

Plate geometry:

D = hole diameter = 70 mm

W = plate width = 100 mm

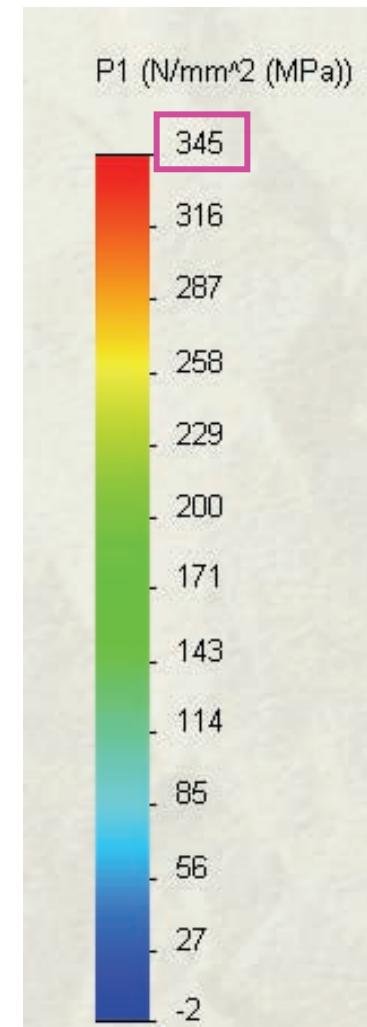
T = plate thickness = 10 mm

Load:

P = tensile load = 50,000 N

$$\therefore \sigma_{\max} = 338 \text{ MPa}$$

FEA Solution

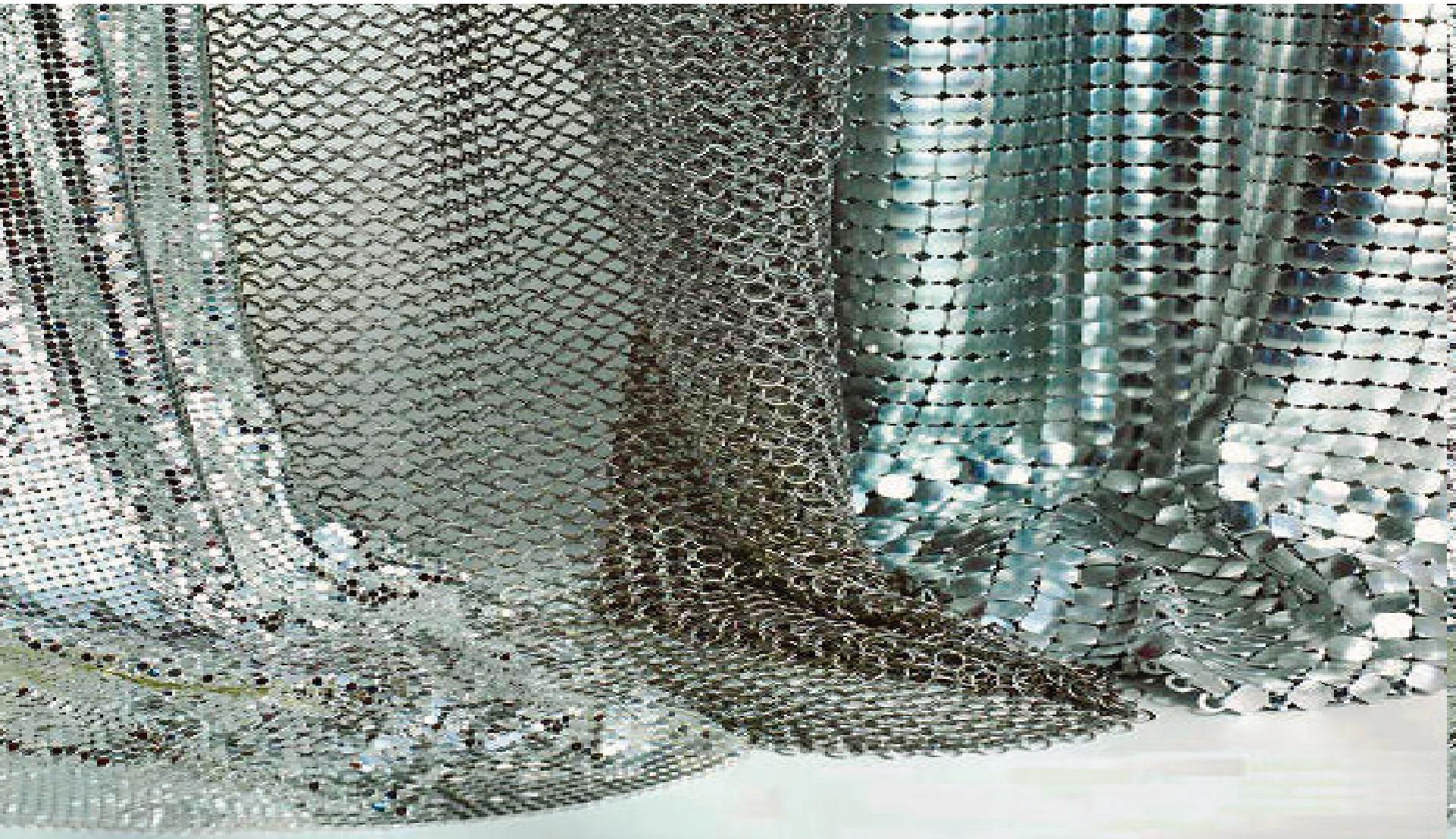


Flat Plate: vonMises (MPa) vs DOF

Mesh	vonMises*	DOF
• Coarse	327	7,944
• Default	341	46,728
• Fine	349	281,142
• Default w/ mesh ctrl.	348	52,368

$$*\sigma_{eq} = \sqrt{0.5[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2]}$$

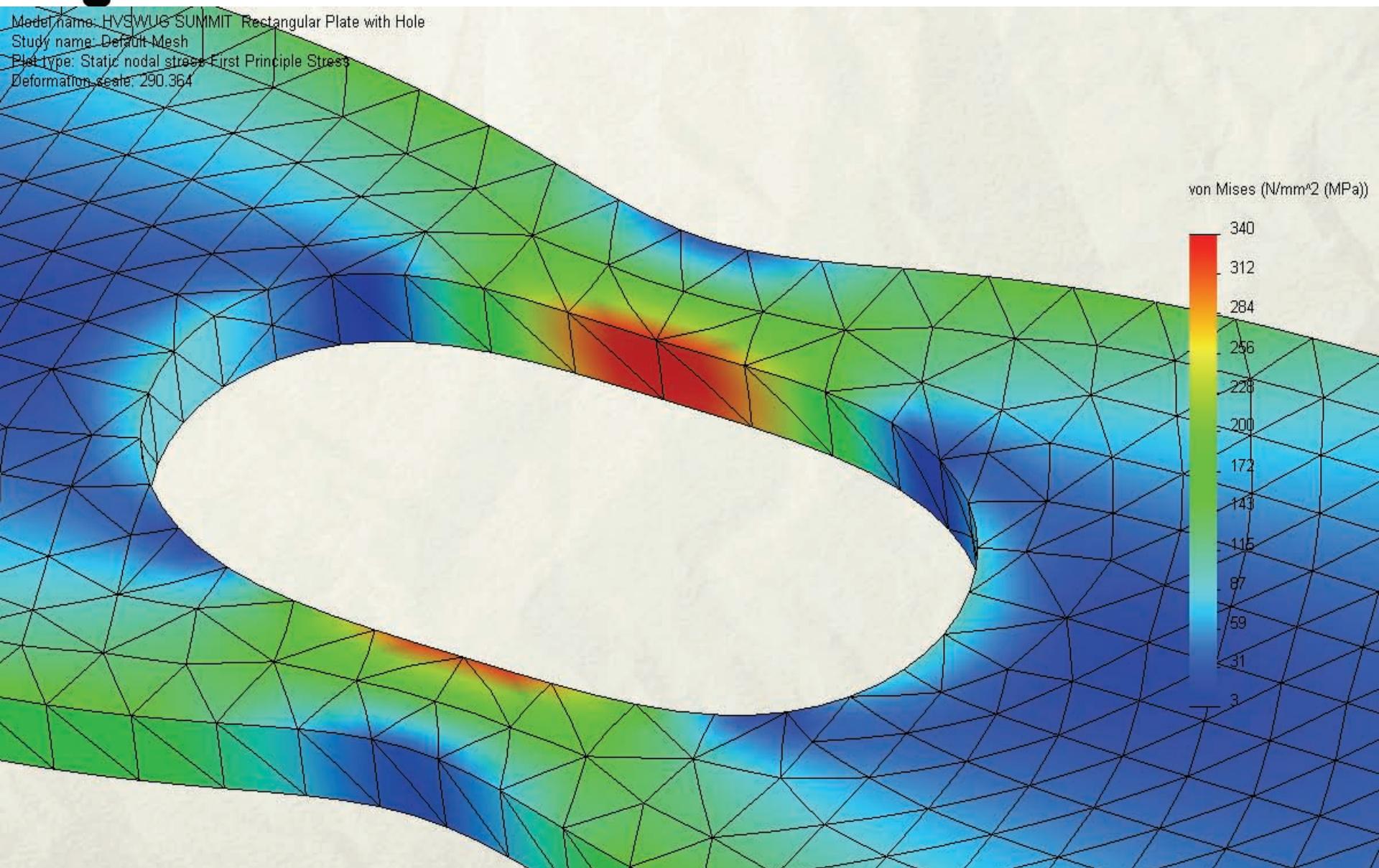
It's all about the Mesh





vonMises (MPa): Default Nodes

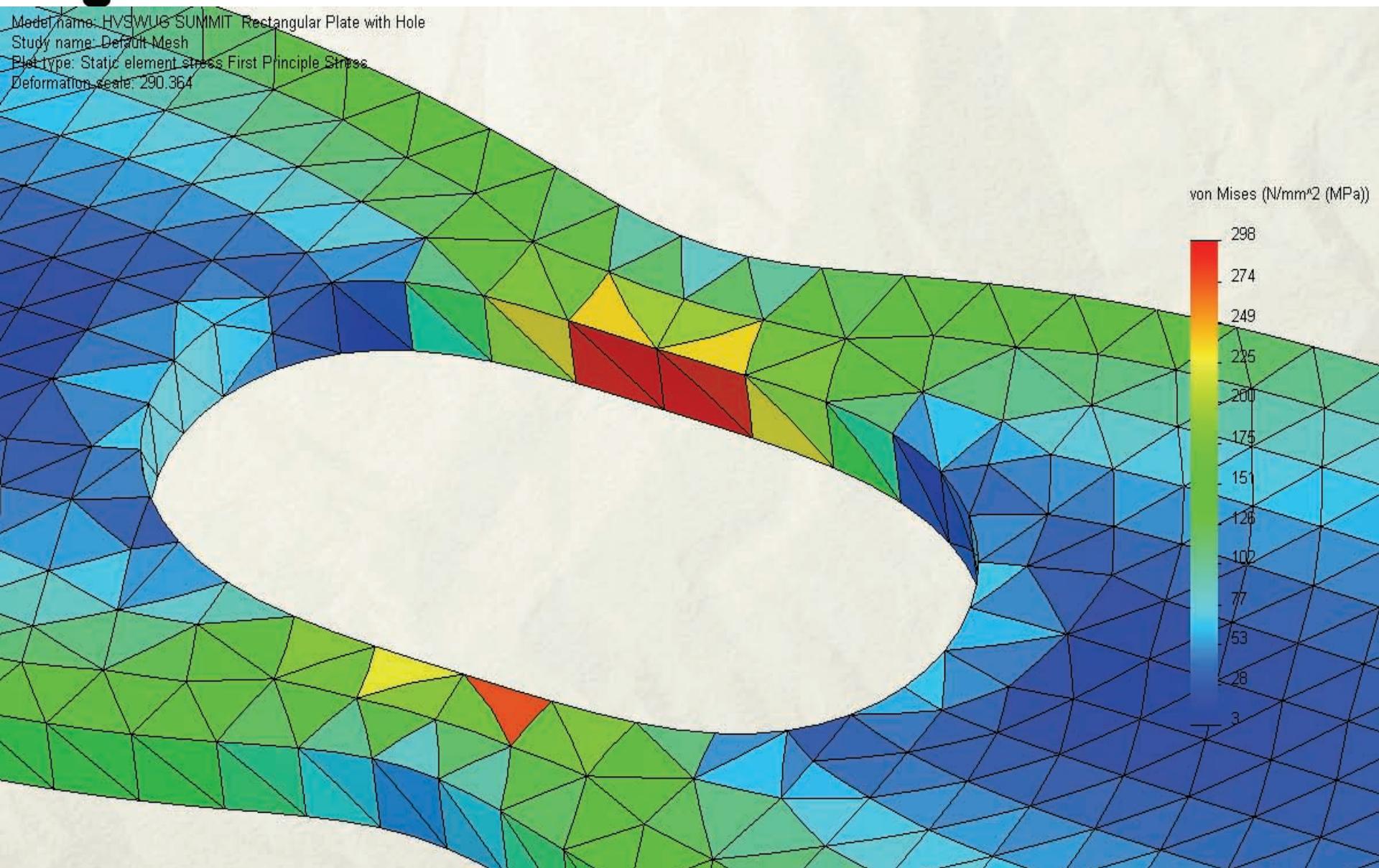
Model name: HVSWUG_SUMMIT Rectangular Plate with Hole
Study name: Default-Mesh
Plot type: Static nodal stress-First Principle Stress
Deformation scale: 290.364





vonMises (MPa): Default Elements

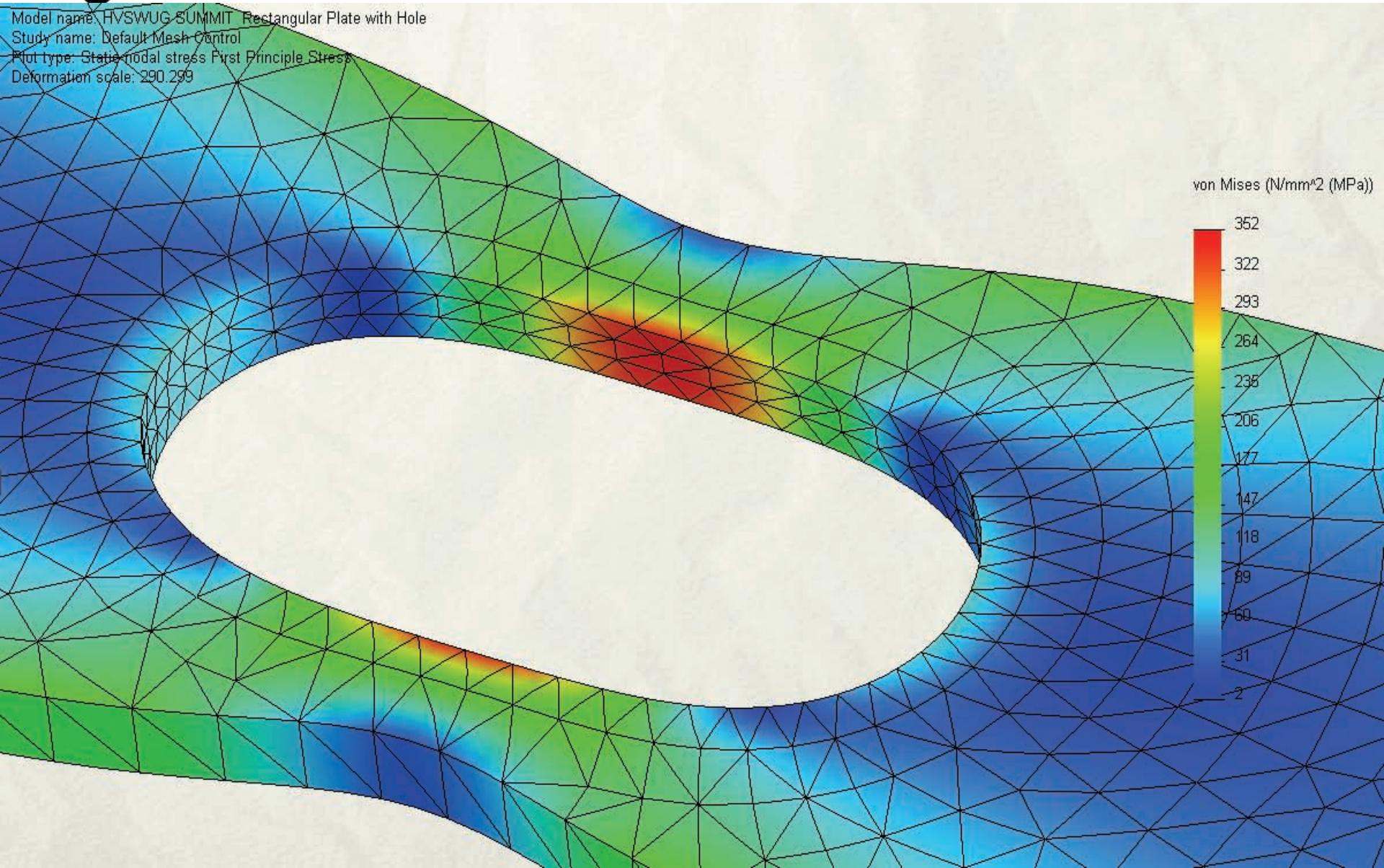
Model name: HVSWUG SUMMIT Rectangular Plate with Hole
Study name: Default Mesh
Plot type: Static element stress First Principle Stress
Deformation scale: 290.364





vonMises (MPa): Fine Nodes

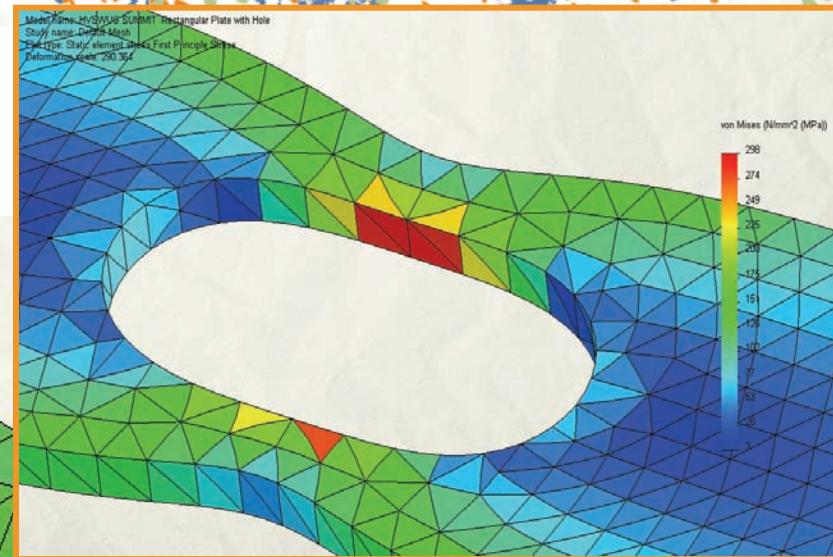
Model name: HVSWUG-SUMMIT Rectangular Plate with Hole
Study name: Default Mesh Control
Plot type: Static modal stress First Principle Stress
Deformation scale: 290.299





vonMises

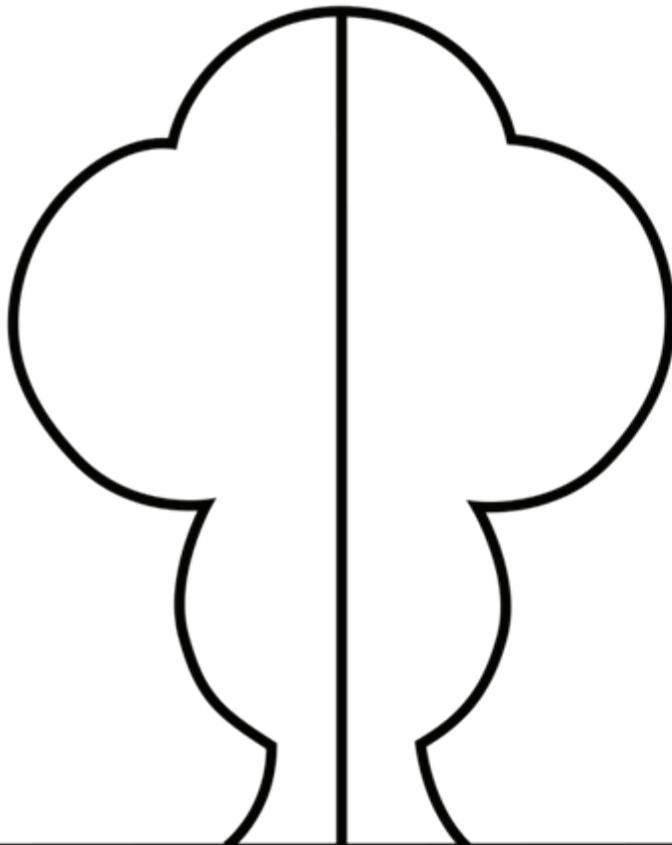
Model name: HVSWUG-SUMMIT Rectangular Plate with Hole
Study name: Default Mesh Control
Plot type: Static element stress First Principle Stress
Deformation scale: 290.299



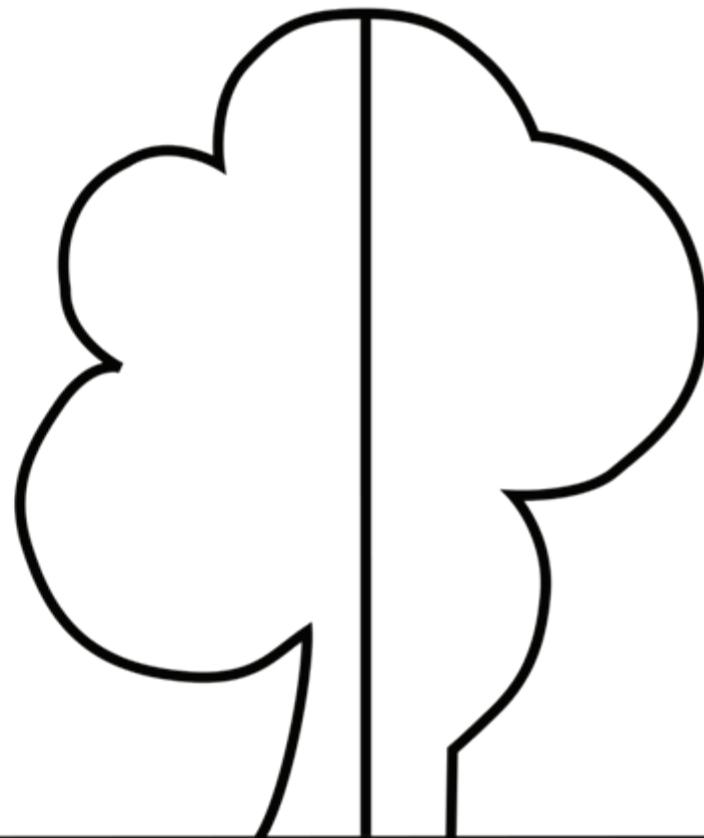
von Mises (N/mm² (MPa))



Consider Symmetry

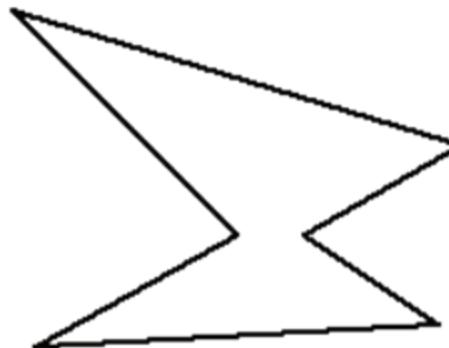
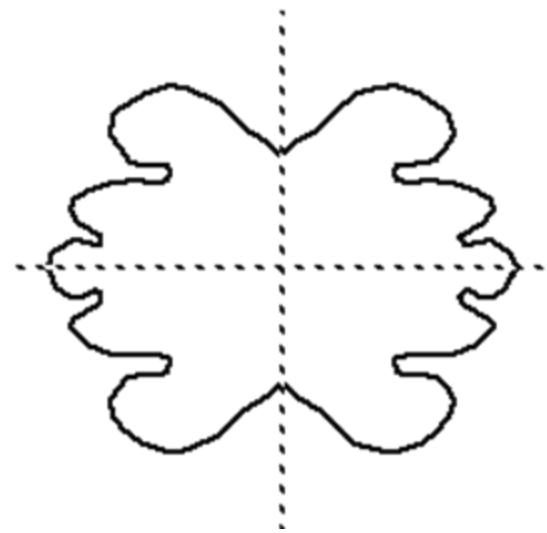
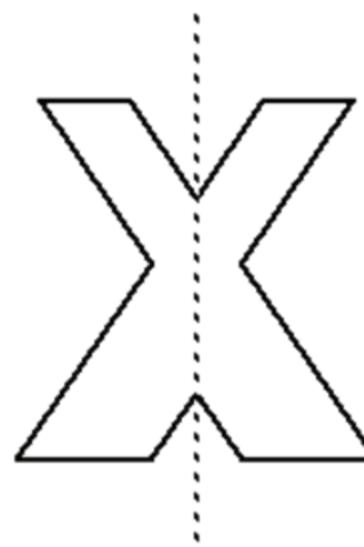
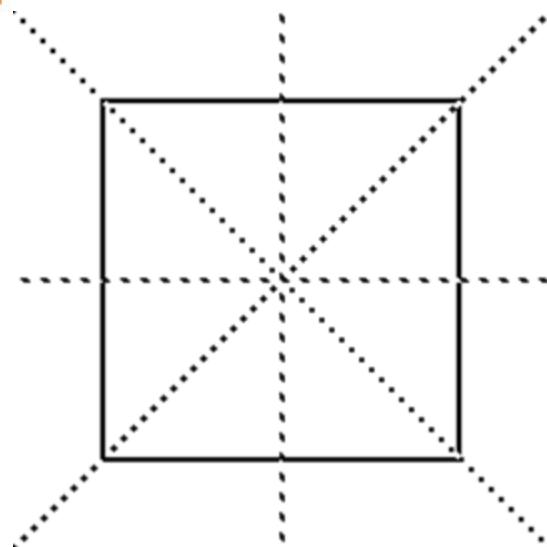


SYMMETRIC

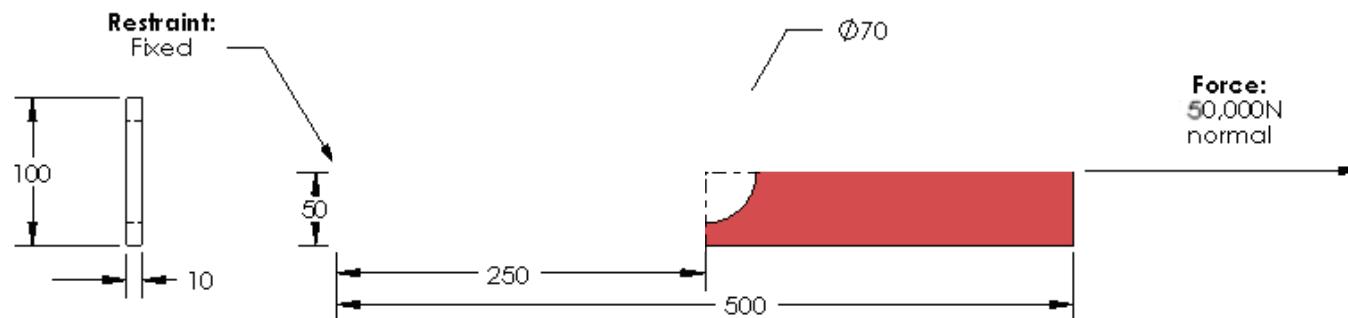


ASYMMETRIC

Consider Symmetry



Consider Symmetry



Material: Alloy Steel Units: MMGS

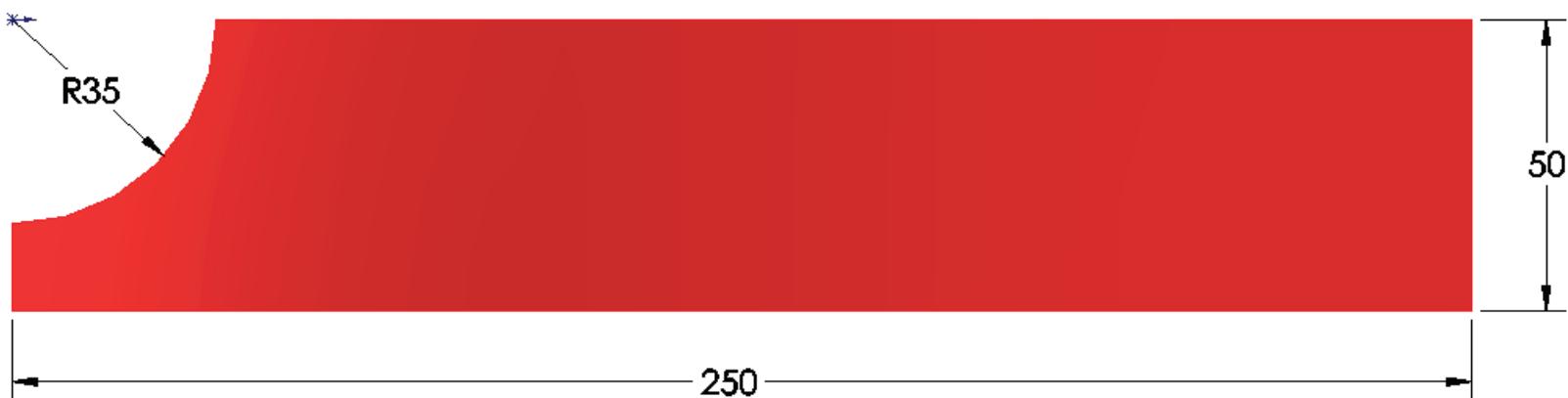
TITLE:	Example 13.1, SWS Rectangular Plate with Hole	
SIZE	Course: EDSGN 496A	REV
A		

SCALE: 1:5

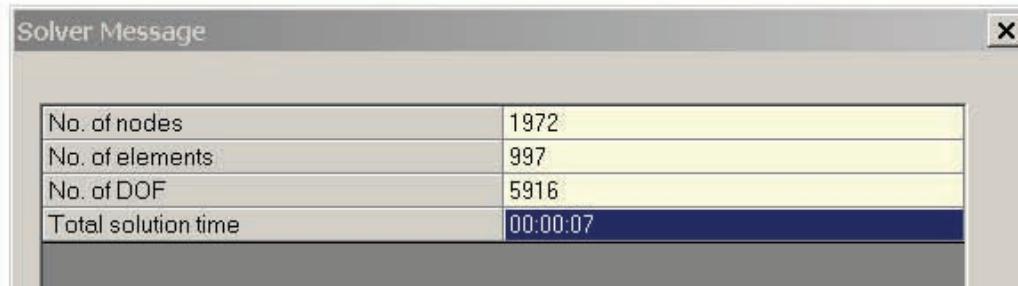
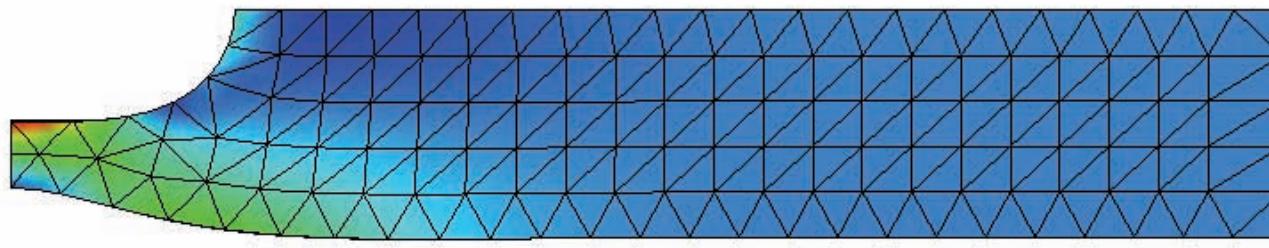
RGB

SHEET 1 OF 1

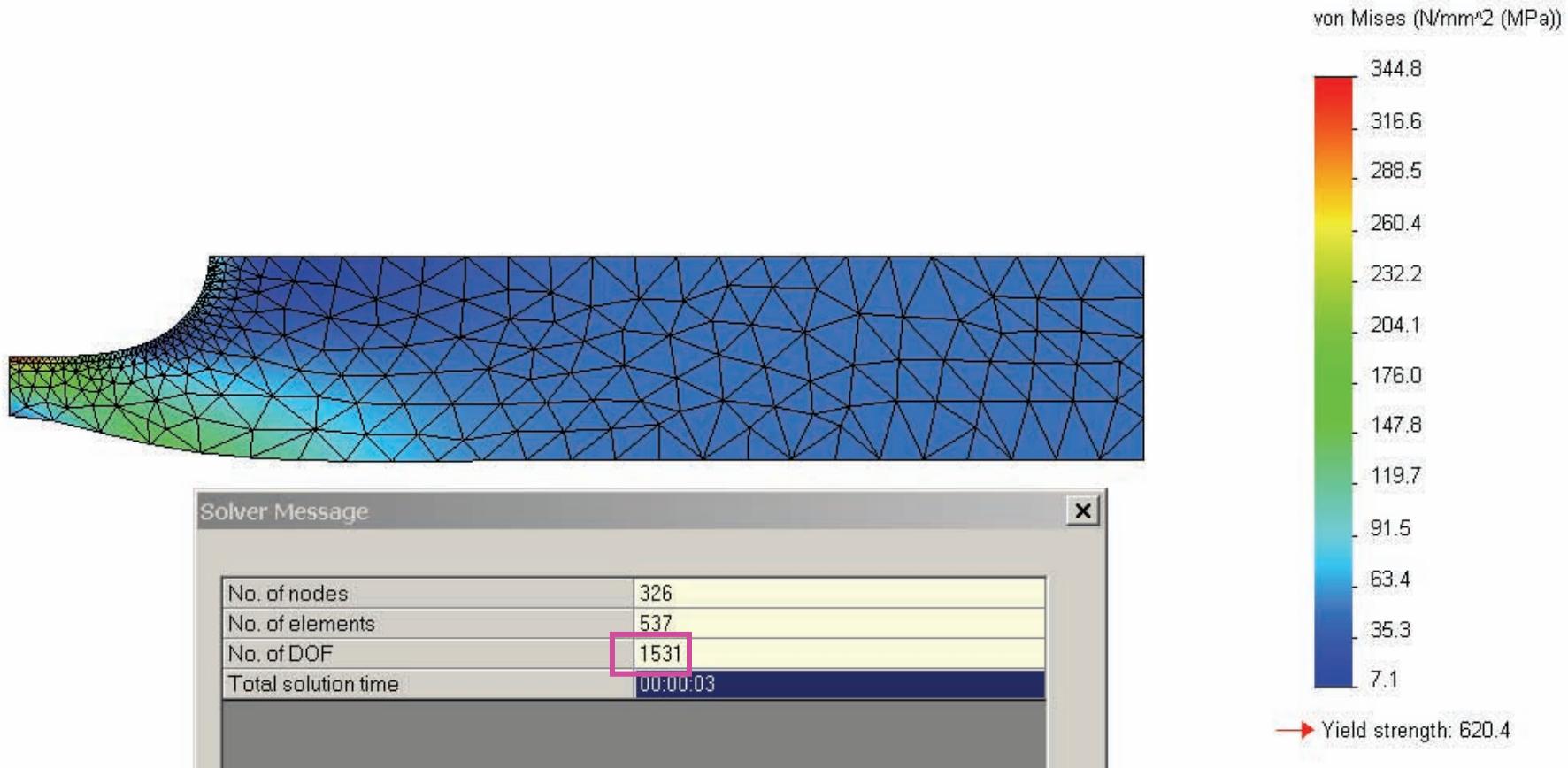
Simplification: $\frac{1}{4}$ Symmetry



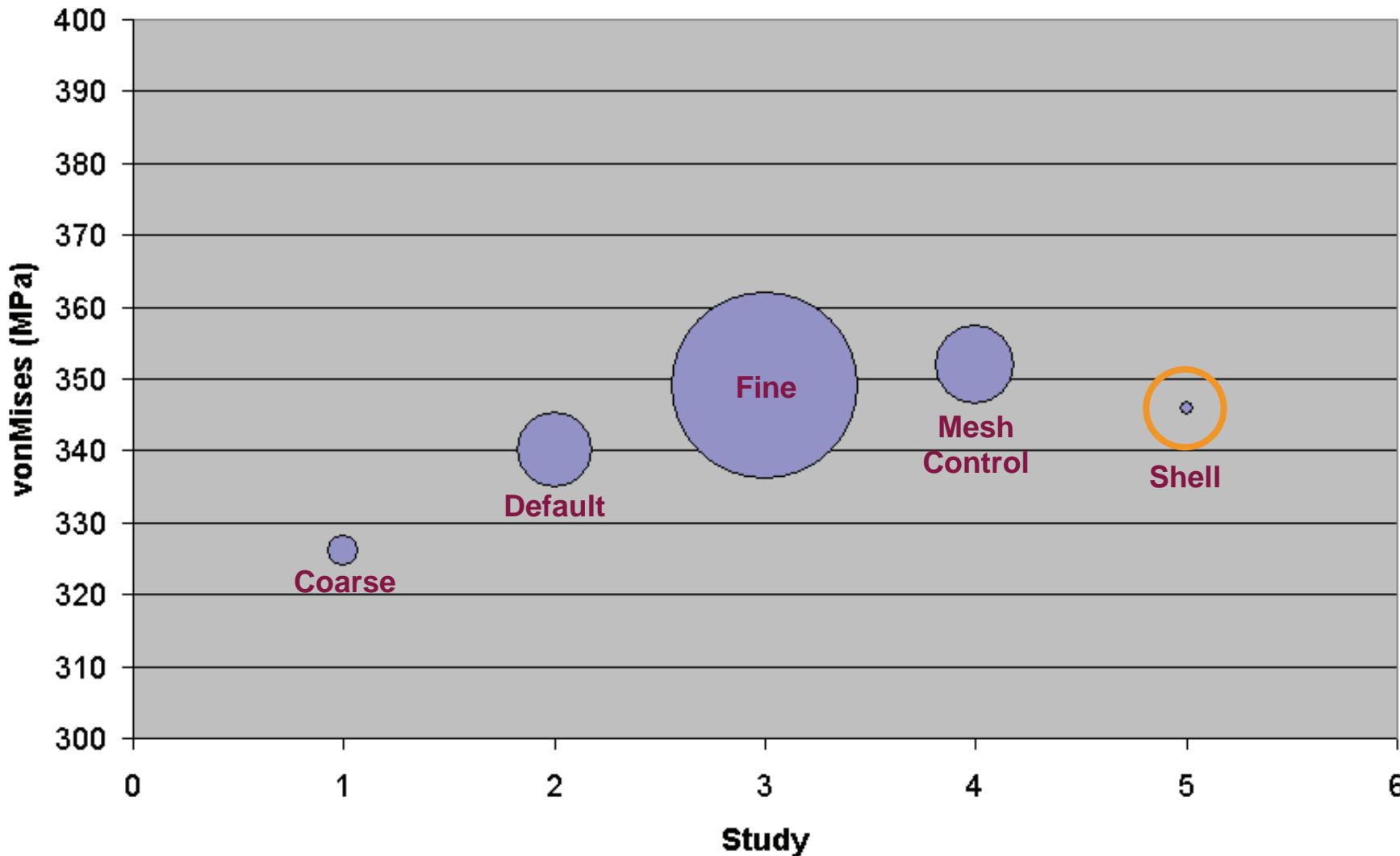
Simplification: $\frac{1}{4}$ Symmetry & 3D



Simplification: $\frac{1}{4}$ Symmetry & 2D



vonMises vs. Degree of Freedom

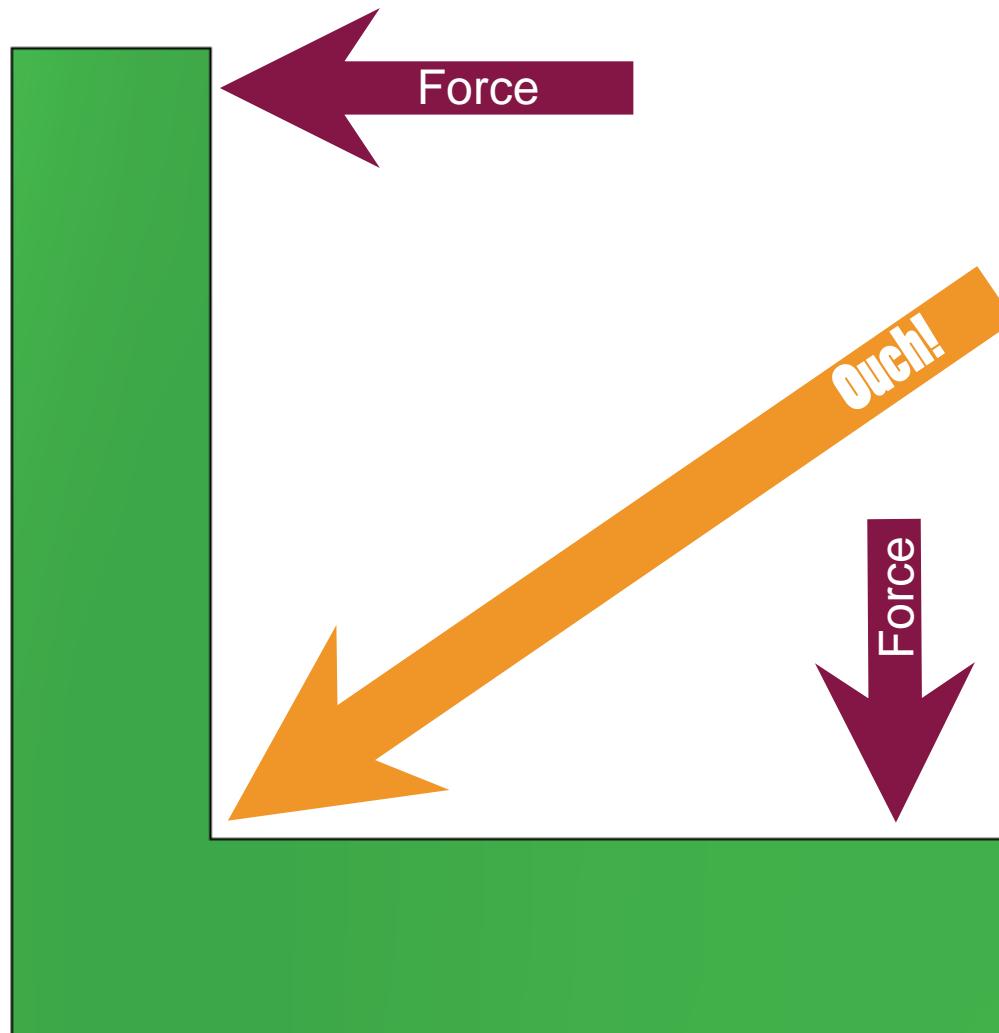


Flat Plate: vonMises (MPa) vs DOF

Mesh	vonMises	DOF
• Coarse	326	7,902
• Default	340	46,581
• Fine	349	280,218
• Default w/ mesh ctrl.	352	52,197
• ¼ Symmetry Shell	347	1,531



Singularity: Reentrant Corner



Consider Singularity: L-Bracket (MPa)

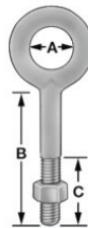
Study	Sharp Corner	Radius Corner
• Mesh Control 1	76	101
• Mesh Control 2	92	101
• Mesh Control 3	194	101
• Adaptive Mesh	-	115

McMaster-Carr

Eyebolts and Eye Nuts

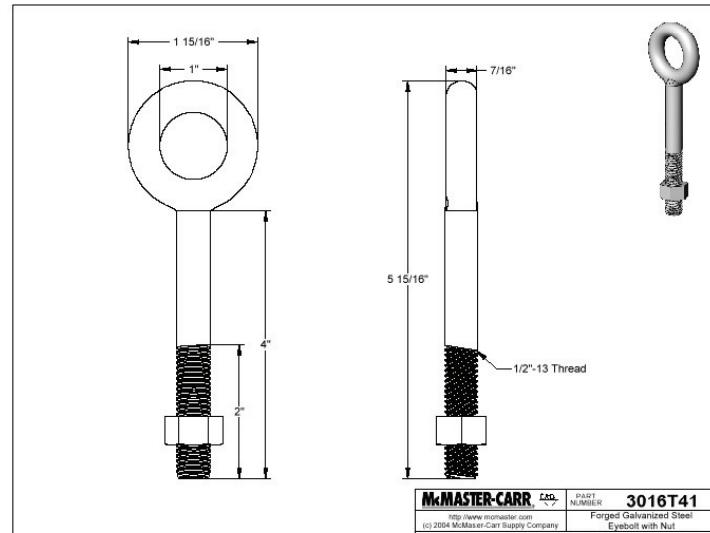
Part Number: 3016T41

\$6.86 Each



Type	Eyebolts with Nuts
Shoulder Type	Without Shoulder
Thread Type	Partially Threaded
Material Type	Steel
Finish	Galvanized
Steel Type	Plain Steel
Thread Size	1/2"-13
Work Load Limit	2,100 lbs.
Dimension A	1"
Dimension B	4"
Dimension C	2"
Specifications Met	Not Rated
Furnished With	One hex nut.

WARNING
Do not exceed work load limits for this item. Any eyebolt that has been modified from its original design will have a reduced work load limit and should be discarded.

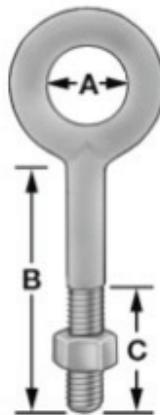


Work Load Limit Given

Eyebolts and Eye Nuts

Part Number: **3016T41**

\$6.86 Each



Type	Eyebolts with Nuts
Shoulder Type	Without Shoulder
Thread Type	Partially Threaded
Material Type	Steel
Finish	Galvanized
Steel Type	Plain Steel
Thread Size	1/2"-13
Work Load Limit	2,100 lbs.
Dimension A	1"
Dimension B	4"
Dimension C	2"
Specifications Met	Not Rated
Furnished With	One hex nut.
WARNING	Do not exceed work load limits for this item. Any eyebolt that has been modified from its original design will have a reduced work load limit and should be discarded.

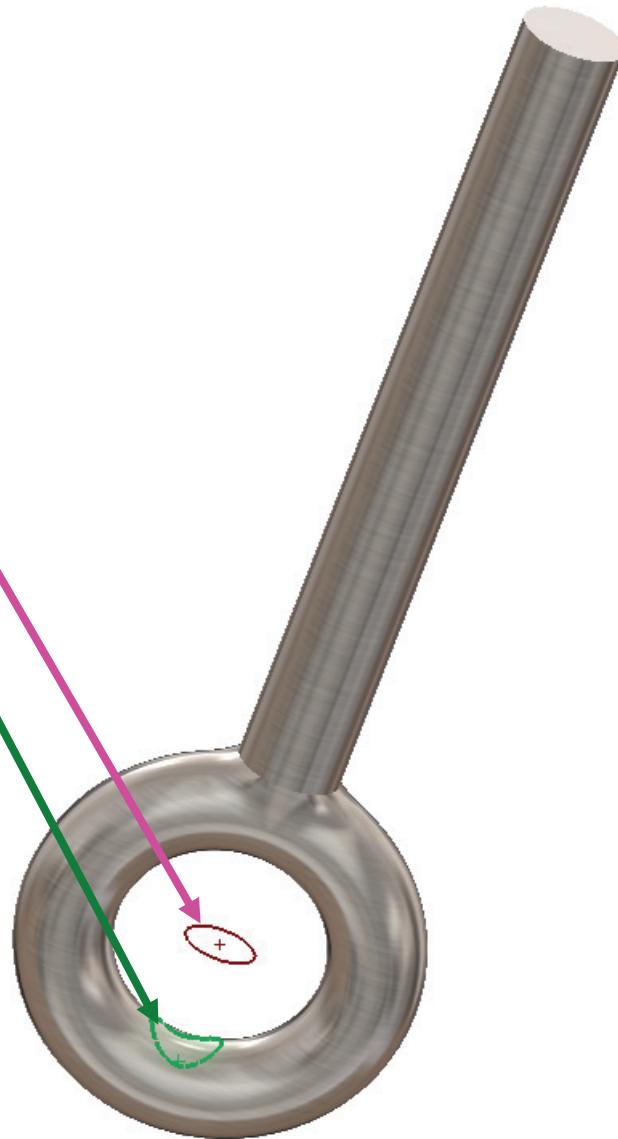
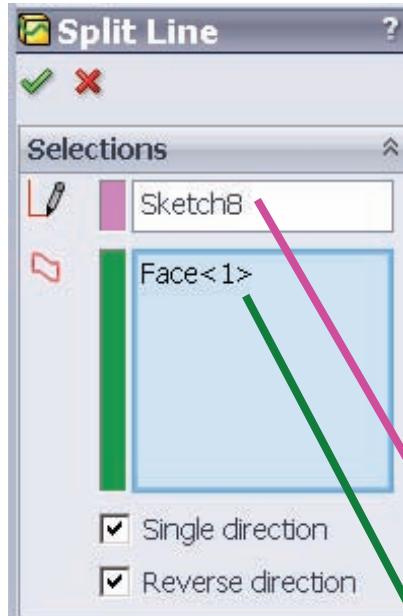
Simplify Geometry



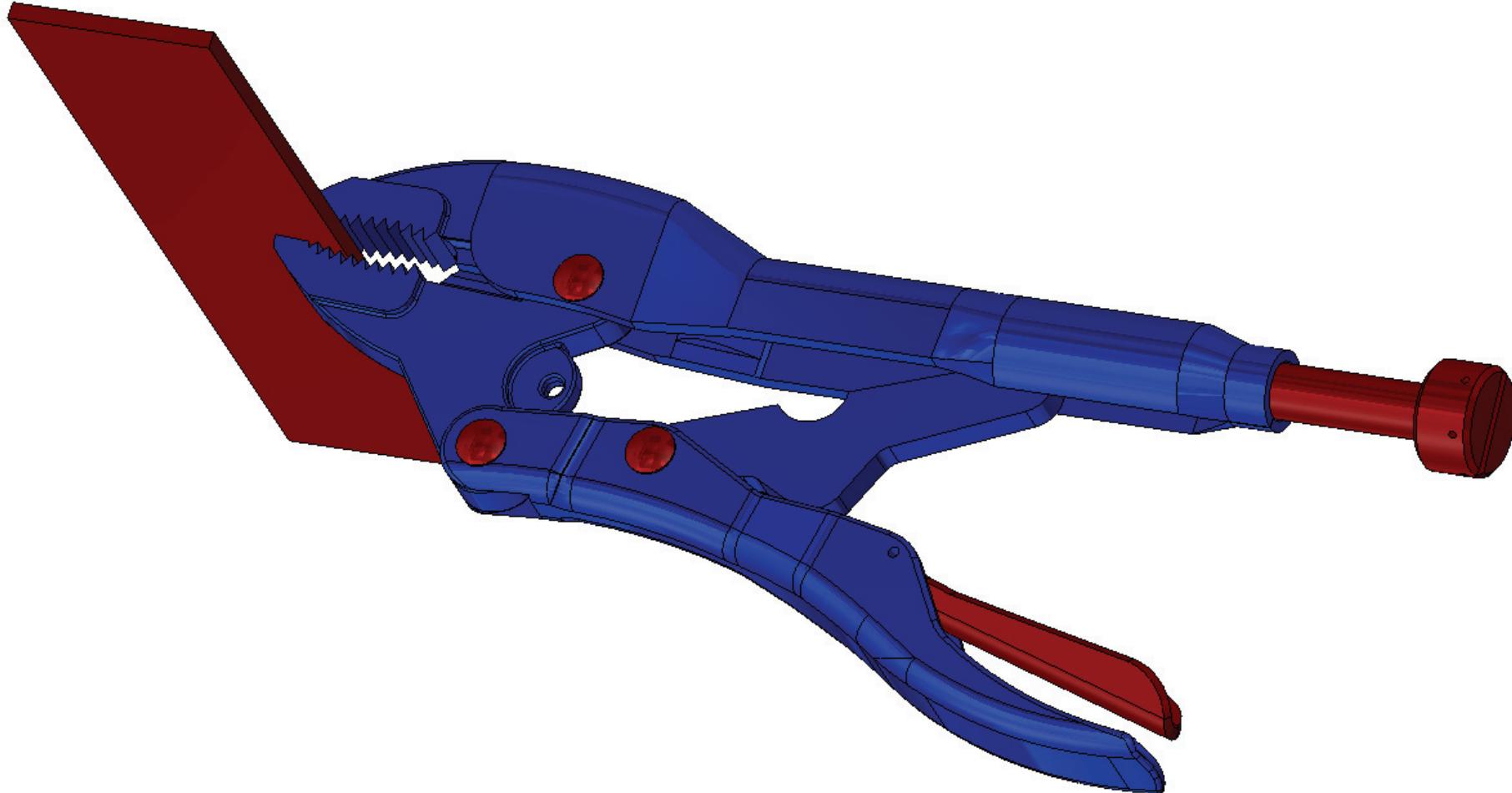
Suppress nut & thread



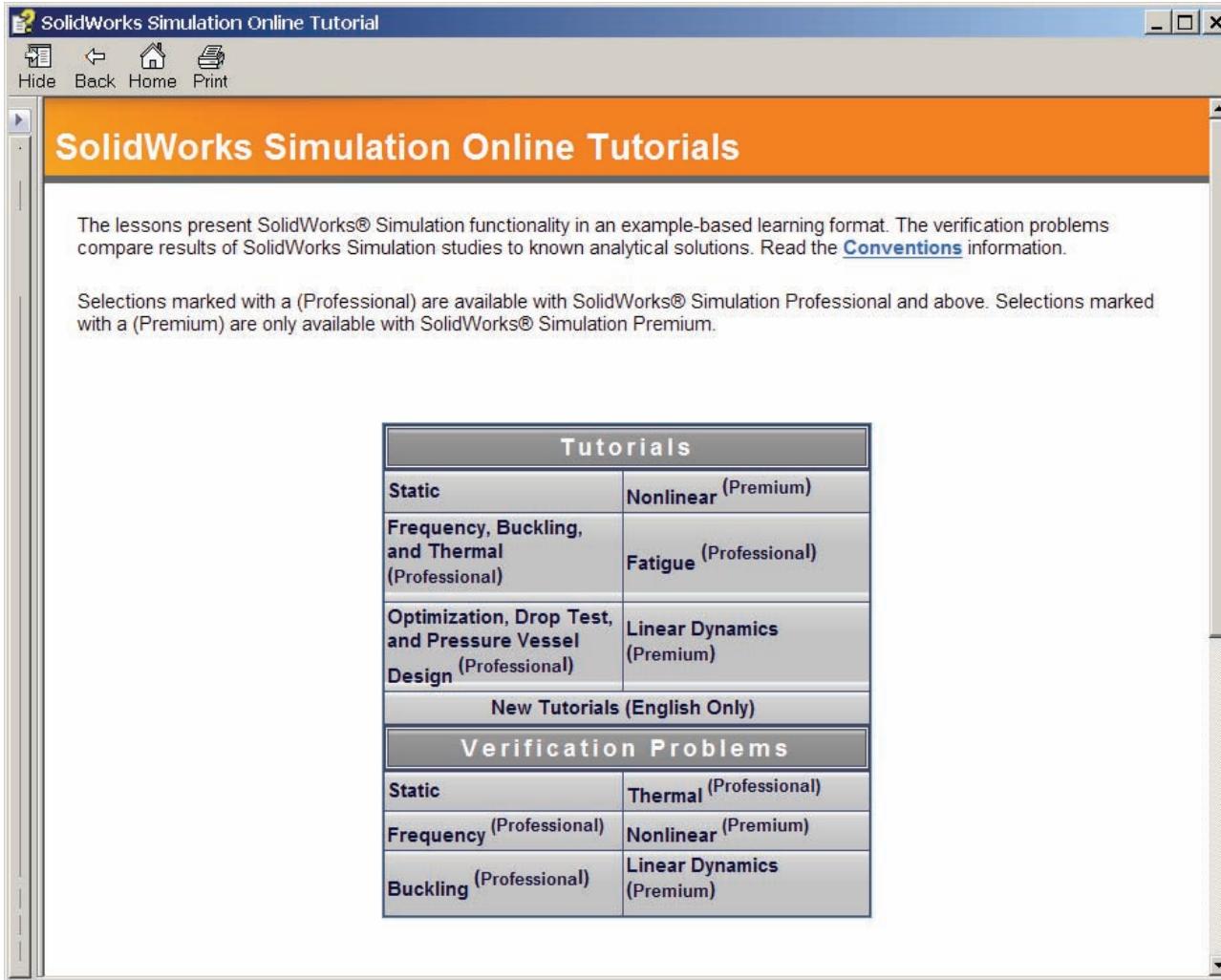
Split Line



Assembly Analysis



SolidWorks Tutorials



The screenshot shows a window titled "SolidWorks Simulation Online Tutorial". The menu bar includes "SolidWorks Simulation Online Tutorial", "File", "Edit", "View", "Tools", "Help", and icons for Hide, Back, Home, and Print.

SolidWorks Simulation Online Tutorials

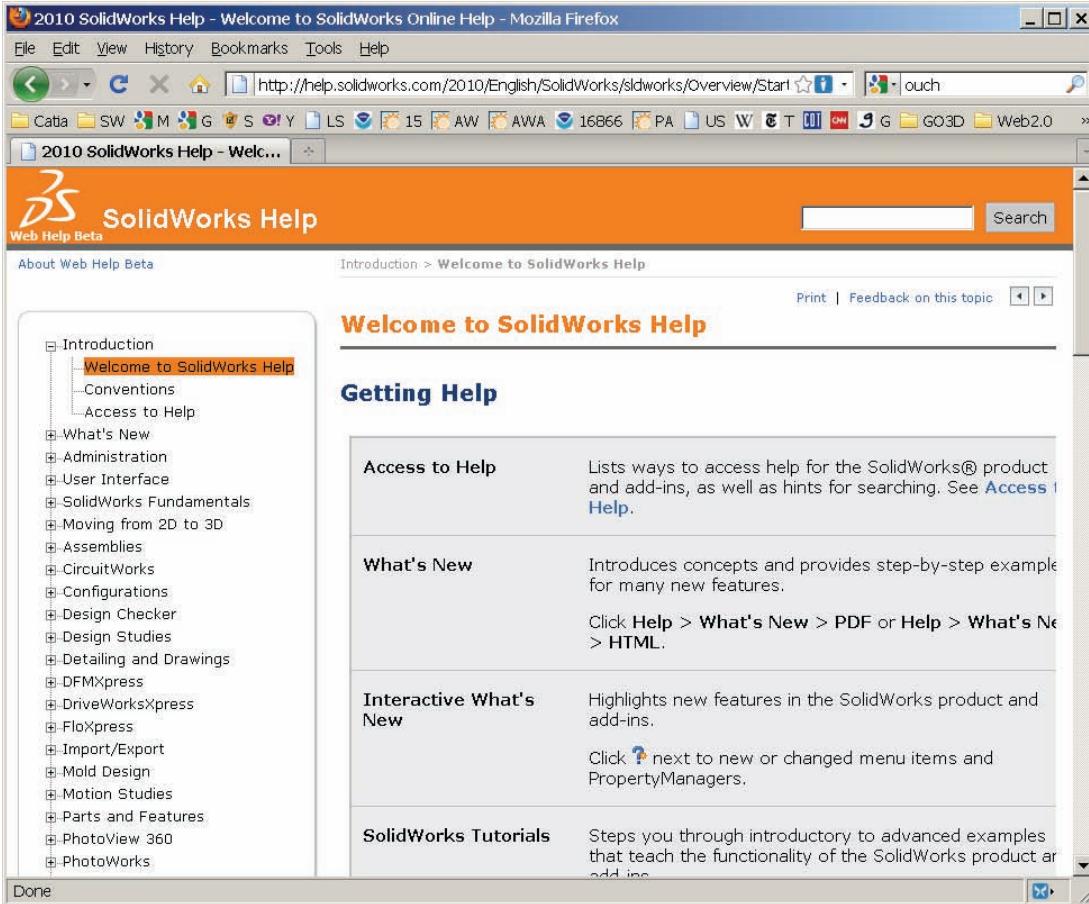
The lessons present SolidWorks® Simulation functionality in an example-based learning format. The verification problems compare results of SolidWorks Simulation studies to known analytical solutions. Read the [Conventions](#) information.

Selections marked with a (Professional) are available with SolidWorks® Simulation Professional and above. Selections marked with a (Premium) are only available with SolidWorks® Simulation Premium.

Tutorials	
Static	Nonlinear (Premium)
Frequency, Buckling, and Thermal (Professional)	Fatigue (Professional)
Optimization, Drop Test, and Pressure Vessel Design (Professional)	Linear Dynamics (Premium)
New Tutorials (English Only)	
Verification Problems	
Static	Thermal (Professional)
Frequency (Professional)	Nonlinear (Premium)
Buckling (Professional)	Linear Dynamics (Premium)

SolidWorks Web Help

- <http://help.solidworks.com/2010/English/SolidWorks/sldworks/Overview/StartPage.htm>



The screenshot shows a Mozilla Firefox browser window displaying the SolidWorks Web Help Beta. The title bar reads "2010 SolidWorks Help - Welcome to SolidWorks Online Help - Mozilla Firefox". The address bar shows the URL "http://help.solidworks.com/2010/English/SolidWorks/sldworks/Overview/StartPage.htm". The page itself has a header "SolidWorks Help" with a search bar. On the left is a navigation tree under "Introduction" with items like "Welcome to SolidWorks Help", "Conventions", "Access to Help", "What's New", "Administration", etc. The main content area is titled "Welcome to SolidWorks Help" and contains sections for "Getting Help", "Access to Help", "What's New", "Interactive What's New", and "SolidWorks Tutorials". Each section provides a brief description and links to further information.

2010 SolidWorks Help - Welcome to SolidWorks Online Help - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://help.solidworks.com/2010/English/SolidWorks/sldworks/Overview/StartPage.htm

2010 SolidWorks Help - Wel...

SolidWorks Help

About Web Help Beta

Introduction > Welcome to SolidWorks Help

Welcome to SolidWorks Help

Getting Help

Access to Help

Lists ways to access help for the SolidWorks® product and add-ins, as well as hints for searching. See [Access to Help](#).

What's New

Introduces concepts and provides step-by-step examples for many new features.

Click [Help > What's New > PDF](#) or [Help > What's New > HTML](#).

Interactive What's New

Highlights new features in the SolidWorks product and add-ins.

Click  next to new or changed menu items and PropertyManagers.

SolidWorks Tutorials

Steps you through introductory to advanced examples that teach the functionality of the SolidWorks product and add-ins.

Done



National Agency for Finite Element Methods and Standards

- NAFEMS Benchmarks...
Help > SolidWorks
Simulation > Validation >
NAFEMS Benchmarks.

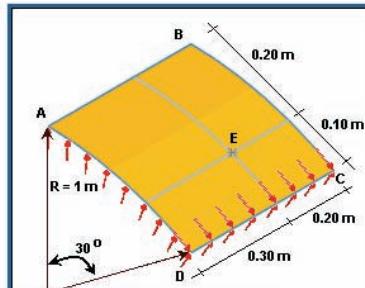
SolidWorks Simulation Online Tutorial

Show Back Home Print

SolidWorks Simulation NAFEMS Verification Problems

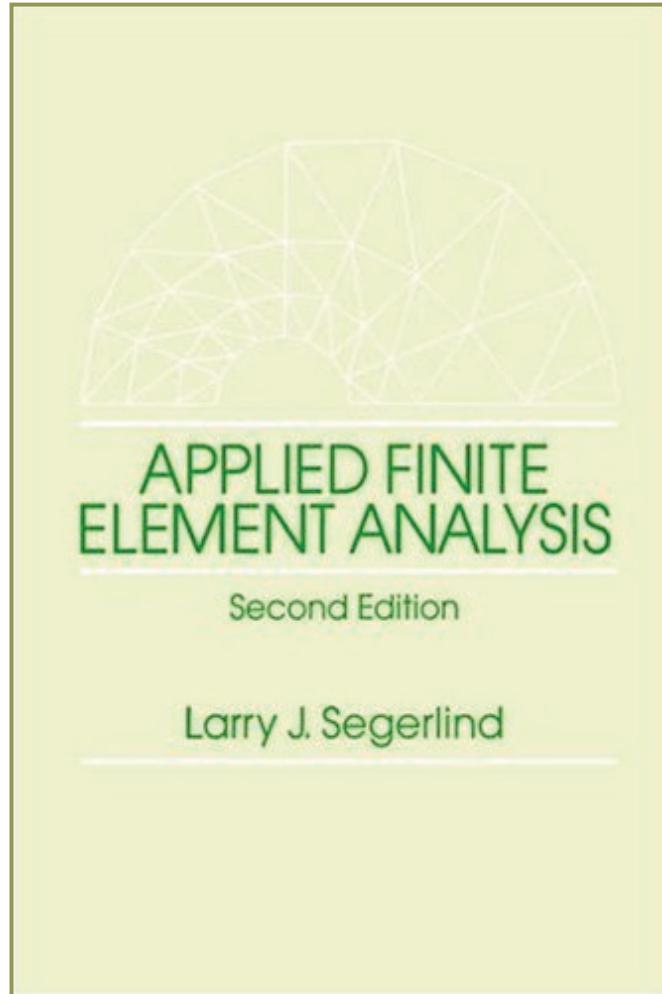
This document contains selected NAFEMS benchmarks for linear static problems.

Cylindrical Shell Under Edge Moment	Cylindrical Shell Under Pressure
Elliptic Membrane Under Pressure	Z-section Cantilever Under Torsion Bending
Skew Plate Under Normal Pressure	Hemisphere Under Point Loads
Composite Laminate Under Three-point Bending	Sandwich Composite Shell Under Pressure



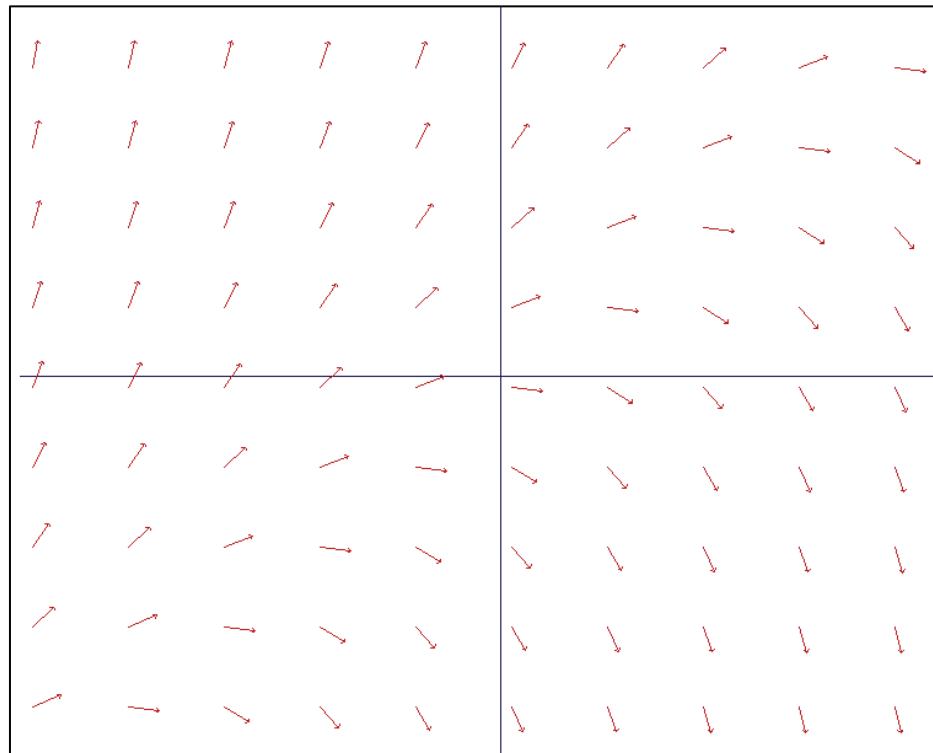
SolidWorks Simulation
Cylindrical Shell Under Pressure
NAFEMS Benchmarks

FEA Reference



Make Math Fun w/ Direction Field Plotter

- <http://www.math.psu.edu/cao/DFD/Dir.html>



Formula Plotter with Integral Curves

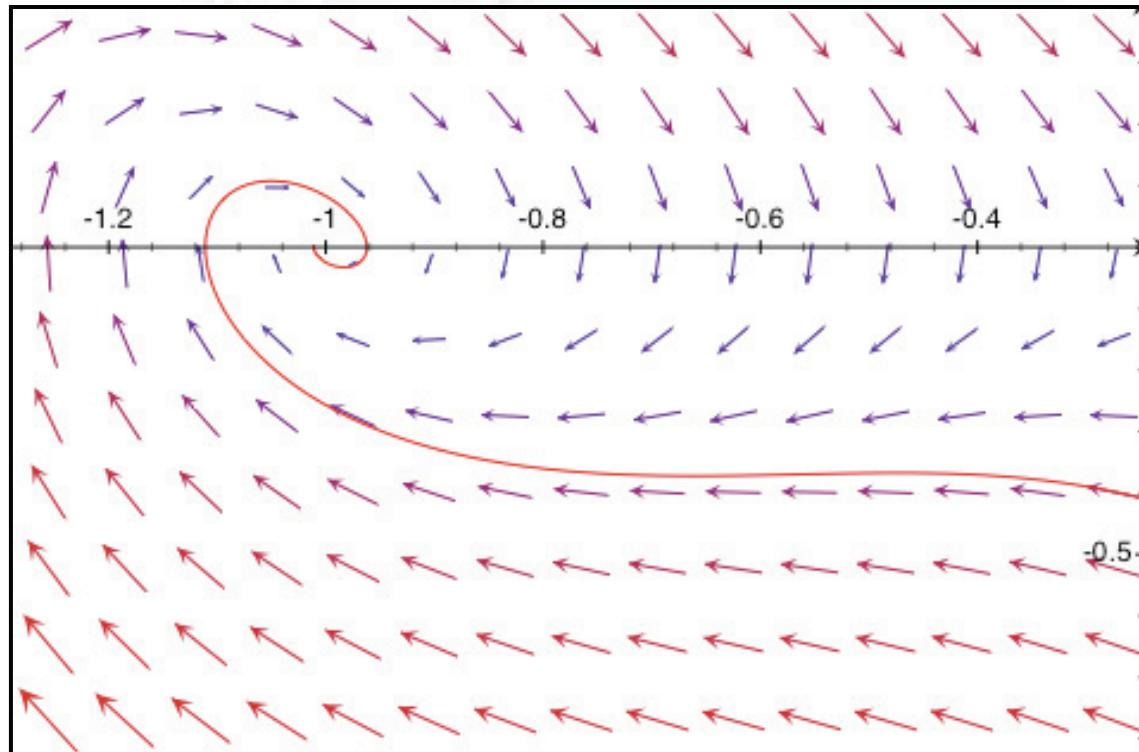


TouchPlot

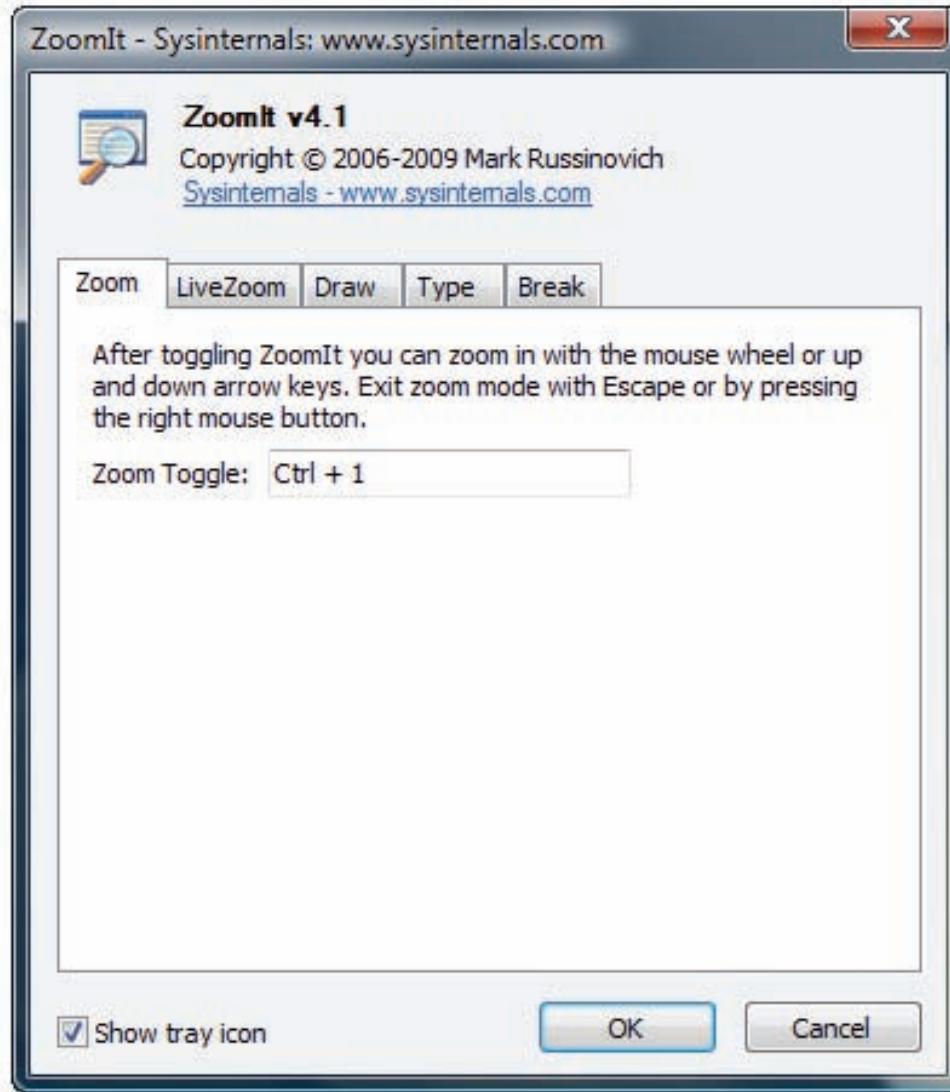
Education

Updated Jan 07, 2010

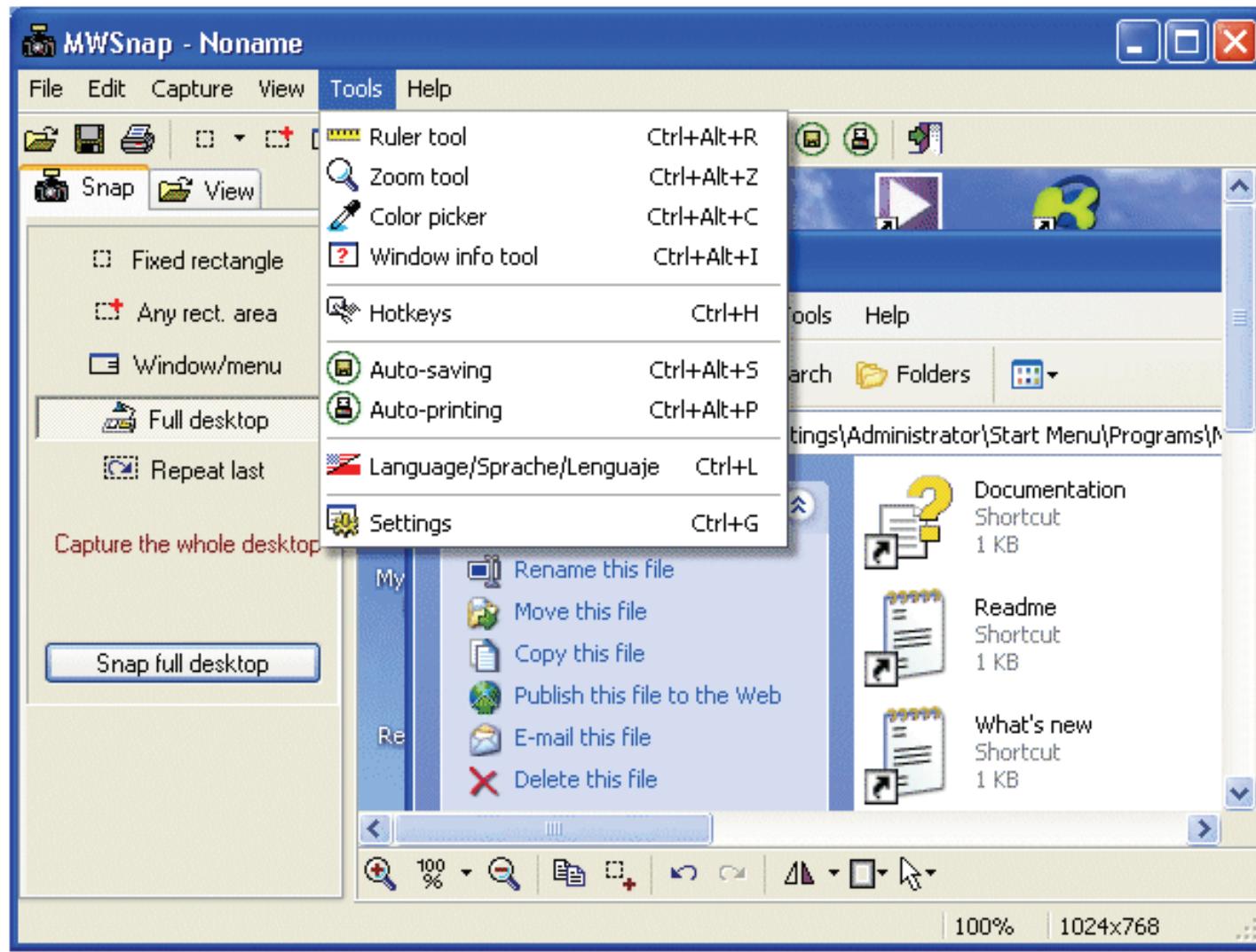
\$0.99 BUY



ZoomIt



MWSnap



This was the Plan

- **SolidWorks Simulation**
 - The Design Cycle
 - Finite Element Method
 - SolidWorks Simulation
 - Defining a Simulation Study
 - Controlling the Mesh
 - Accessing the Results
 - Identifying Singularities
 - Instructional Examples
 - Tips and Tricks

Questions

