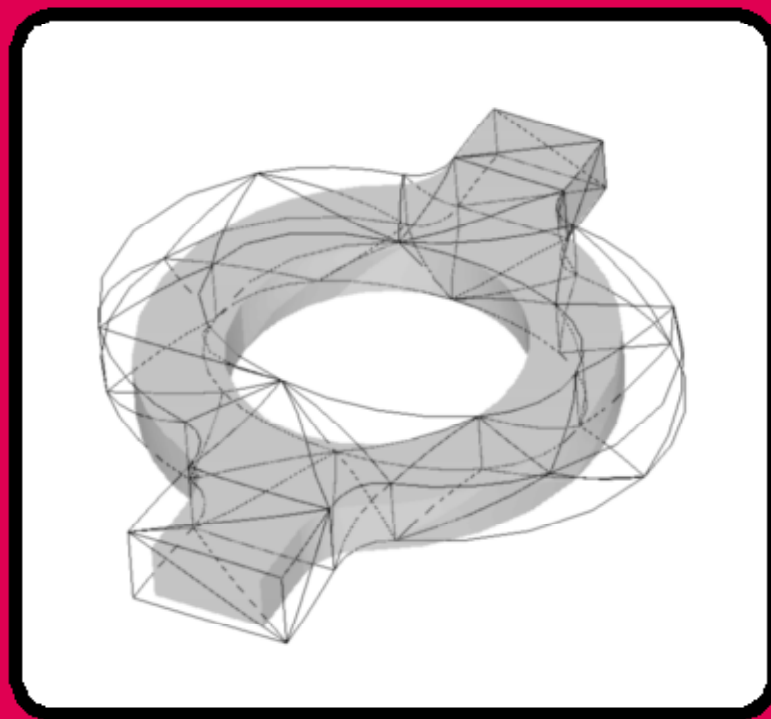


Pro|ENGINEER®
WILD FIRE™ 3.0

MECHANICA Tutorial
(Structure / Thermal)

Integrated Mode



Roger Toogood, Ph.D., P. Eng.

SDC
PUBLICATIONS

Schroff Development Corporation

www.schroff.com
www.schroff-europe.com

TABLE OF CONTENTS

Preface	i
Note to Instructors	iii
Organization and Synopsis of Tutorials	iv
Acknowledgments	viii
Table of Contents	ix

Chapter 1 - Introduction to the Tutorials

Overview	1 - 1
Finite Element Analysis	1 - 1
Examples of Problems Solved using MECHANICA	1 - 3
Example #1 : Analysis	1 - 3
Example #2 : Sensitivity Study	1 - 4
Example #3 : Design Optimization	1 - 5
FEA User Beware!	1 - 7
Tips for using MECHANICA	1 - 9
Table 1-1 Common Mouse Functions	1 - 10
Questions for Review	1 - 11
Exercises	1 - 11

Chapter 2 - Finite Element Modeling with MECHANICA

Overview of this Lesson	2 - 1
Finite Element Analysis : An Introduction	2 - 1
The FEA Model and General Processing Steps	2 - 4
Steps in Preparing an FEA Model for Solution	2 - 6
P-Elements versus H-Elements	2 - 8
Convergence of H-elements (the “classic” approach)	2 - 8
Convergence of P-elements (the MECHANICA approach)	2 - 10
Convergence and Accuracy in the Solution	2 - 11
Sources of Error	2 - 12
A CAD Model is <i>NOT</i> an FEA Model!	2 - 13
Overview of MECHANICA Structure/Thermal	2 - 14
Basic Operation	2 - 14
TABLE I - An Overall View of MECHANICA Capability and Function	2 - 15
Modes of Operation	2 - 16
TABLE II - MECHANICA Modes of Operation	2 - 17
Types of Models	2 - 17
Types of Elements	2 - 17
Analysis Methods	2 - 18
Convergence Methods	2 - 18
Design Studies	2 - 19

A Brief Note about Units	2 - 19
TABLE III - Common unit systems in MECHANICA	2 - 20
Files and Directories Produced by MECHANICA	2 - 20
Table IV - Some Files Produced by MECHANICA	2 - 21
On-line Documentation	2 - 22
Process Guide	2 - 22
Summary	2 - 22
References	2 - 23
Questions for Review	2 - 24
Exercises	2 - 24

Chapter 3 - Solid Models (Part 1)

Overview of this Lesson	3 - 1
Simple Static Analysis of a Solid Part	3 - 1
Creating the Geometry of the Model	3 - 2
Setting up the FEA Model	3 - 3
Launching MECHANICA	3 - 3
Applying the Constraints	3 - 5
Applying the Loads	3 - 7
Specifying the Material	3 - 8
Setting up the Analysis	3 - 9
Setting Up and Running the Analysis	3 - 11
Displaying the Results	3 - 14
Creating Result Window Definitions	3 - 14
Showing the Result Windows	3 - 20
Simulation Features in the Model Tree	3 - 25
Exploring the FEA Mesh and AutoGEM	3 - 26
Running the Model in MECHANICA Independent Mode	3 - 31
Summary	3 - 33
Questions for Review	3 - 34
Exercises	3 - 35

Chapter 4 - Solid Models (Part 2)

Overview of this Lesson	4 - 1
Standard Design Studies	4 - 2
Creating a Design Variable	4 - 3
Sensitivity Design Studies	4 - 5
Running the Sensitivity Study	4 - 7
Displaying the Sensitivity Results	4 - 7
Showing the Result Windows	4 - 8
Optimization	4 - 9
Creating Design Variables	4 - 10
Important Considerations for the Search Space	4 - 11
Running the Optimization Design Study	4 - 12
Optimization Results	4 - 13

Considerations for Applying Loads and Constraints	4 - 16
Superposition and Multiple Load Sets	4 - 20
Creating Multiple Load Sets	4 - 21
Setting the Analysis for Multiple Load Sets	4 - 21
Combining Results for Multiple Load Sets	4 - 23
Summary	4 - 25
Questions for Review	4 - 26
Exercises	4 - 26

Chapter 5 - Plane Stress and Plane Strain Models

Overview of this Lesson	5 - 1
Plane Stress Models	5 - 2
Creating a Coordinate System	5 - 3
Setting the Model Type	5 - 3
Applying Loads and Constraints	5 - 4
Defining Model Properties	5 - 5
Setting up and Running the Analysis	5 - 6
Viewing the Results	5 - 6
Exploring Symmetry	5 - 8
Setting Constraints and Loads	5 - 8
Running the Symmetric Half-Model	5 - 10
Plane Strain Models	5 - 12
The Model	5 - 12
Creating the Pro/E Part	5 - 13
Creating Surface Regions	5 - 13
Creating a Cylindrical Coordinate System	5 - 14
Applying the Constraints	5 - 15
Applying a Pressure Load	5 - 16
Applying a Temperature Load	5 - 16
Specifying Materials	5 - 17
Running the Model	5 - 17
Quick Check Analysis	5 - 17
Multi-Pass Adaptive Analysis	5 - 18
Viewing the Results	5 - 19
Summary	5 - 20
Questions for Review	5 - 21
Exercises	5 - 22

Chapter 6 - Axisymmetric Solids and Shells

Overview of this Lesson	6 - 1
Axisymmetric Models	6 - 1
Elements	6 - 2
Loads	6 - 2
Constraints	6 - 3
Restrictions	6 - 3

Axisymmetric Solids	6 - 3
Creating the Model	6 - 3
Setting the Model Type	6 - 4
Applying Constraints	6 - 5
Applying Loads	6 - 5
Defining Material Properties	6 - 6
Setting up and Running the Analysis	6 - 6
Viewing the Results	6 - 7
Exploring the Model	6 - 8
Changing the Mesh with AutoGEM	6 - 8
Changing the Mesh with Detailed Fillet Modeling	6 - 9
Methods for Controlling the Mesh	6 - 11
Comparing to a Solid Model	6 - 14
Axisymmetric Shells	6 - 17
Creating the Model	6 - 17
Setting the Model Type	6 - 18
Setting Constraints	6 - 19
Setting a Centrifugal Load	6 - 19
Defining Shell Properties	6 - 20
Running the Analysis	6 - 21
View the Results	6 - 22
Modifying the Model	6 - 23
Running the Modified Model	6 - 25
Pressure Loads on Axisymmetric Shells	6 - 26
Summary	6 - 28
Questions for Review	6 - 29
Exercises	6 - 30

Chapter 7 - Shell Models

Overview of this Lesson	7 - 1
Automatic Shell Creation (Model #1)	7 - 2
Creating the Geometry	7 - 2
Defining the Shells	7 - 2
Assigning the Material	7 - 4
Assigning the Constraints	7 - 4
Assigning a Pressure Load	7 - 5
Defining and Running the Analysis	7 - 6
Viewing the Results	7 - 6
Exploring the Model	7 - 7
Manual Shell Creation (Model #2)	7 - 8
Creating the Model	7 - 8
Defining Surface Pairs	7 - 9
Completing the Model	7 - 10
Running the Model	7 - 11

Mixed Solids and Shells (Model #3)	7 - 15
Creating the Shells	7 - 16
Defining the Constraints	7 - 18
Defining a Bearing Load	7 - 19
Defining the Material	7 - 19
Running the Analysis	7 - 20
Reviewing the Results	7 - 20
Summary	7 - 22
Questions for Review	7 - 23
Exercises	7 - 24

Chapter 8 - Beams and Frames

Overview of this Lesson	8 - 1
Beam Coordinate Systems	8 - 1
The Beam Action Coordinate System BACS	8 - 2
The Beam Shape Coordinate System BSCS	8 - 2
Example #1 - Basic Concepts	8 - 4
The Model	8 - 4
Beam Elements	8 - 5
Completing the Model	8 - 7
Constraints	8 - 7
Loads	8 - 7
Analysis and Results	8 - 8
Deformation and Bending Stress	8 - 8
Shear Force and Moment Diagrams	8 - 9
Changing the Constraint	8 - 10
Example #2 - Distributed Loads, Beam Releases	8 - 11
The Model	8 - 11
Beam Elements	8 - 13
Completing the Model	8 - 14
Constraints	8 - 14
Distributed Loads	8 - 14
Analysis and Results	8 - 17
Beam Releases	8 - 19
Setting Releases	8 - 19
Example #3 - Frames	8 - 21
Model A - 2D Frame	8 - 21
Beam Elements	8 - 22
Completing the Model	8 - 23
Analysis and Results	8 - 25
Model B - 3D Frame	8 - 26
Modifying the Model	8 - 26
Creating Beam Elements	8 - 27
Completing the Model	8 - 28
Analysis and Results	8 - 29
Displacement Constraint	8 - 29

Summary	8 - 31
Questions for Review	8 - 32
Exercises	8 - 34

Chapter 9 - Miscellaneous Topics

Overview of this Lesson	9 - 1
Cyclic Symmetry	9 - 1
Model Geometry	9 - 2
Cyclic Constraints	9 - 3
Analysis and Results	9 - 4
Springs and Masses	9 - 6
Model Geometry	9 - 7
Creating the Elements	9 - 8
Analysis and Results	9 - 10
Defining Measures	9 - 11
Modal Analysis	9 - 12
Setting up the Model	9 - 12
Defining the Modal Analysis	9 - 13
Contact Analysis	9 - 15
Creating Contact Regions	9 - 17
Summary	9 - 19
Questions for Review	9 - 20
Exercises	9 - 21

Chapter 10 - Thermal Models

Overview of this Lesson	10 - 1
Overview of THERMAL	10 - 1
What can THERMAL do?	10 - 2
Why use THERMAL?	10 - 3
Material Properties	10 - 3
Model Types and Idealizations	10 - 4
More on Boundary Conditions	10 - 4
More on Heat Loads	10 - 5
A Note about Units	10 - 6
Steady State Models	10 - 7
3D Solid Model	10 - 7
2D Plate Model	10 - 11
Transient Analysis	10 - 16
Thermally Induced Stresses	10 - 20
Creating the Thermal Model	10 - 21
Creating the Structure Model	10 - 22
Summary	10 - 24
Conclusion	10 - 25
Questions for Review	10 - 27
Exercises	10 - 27