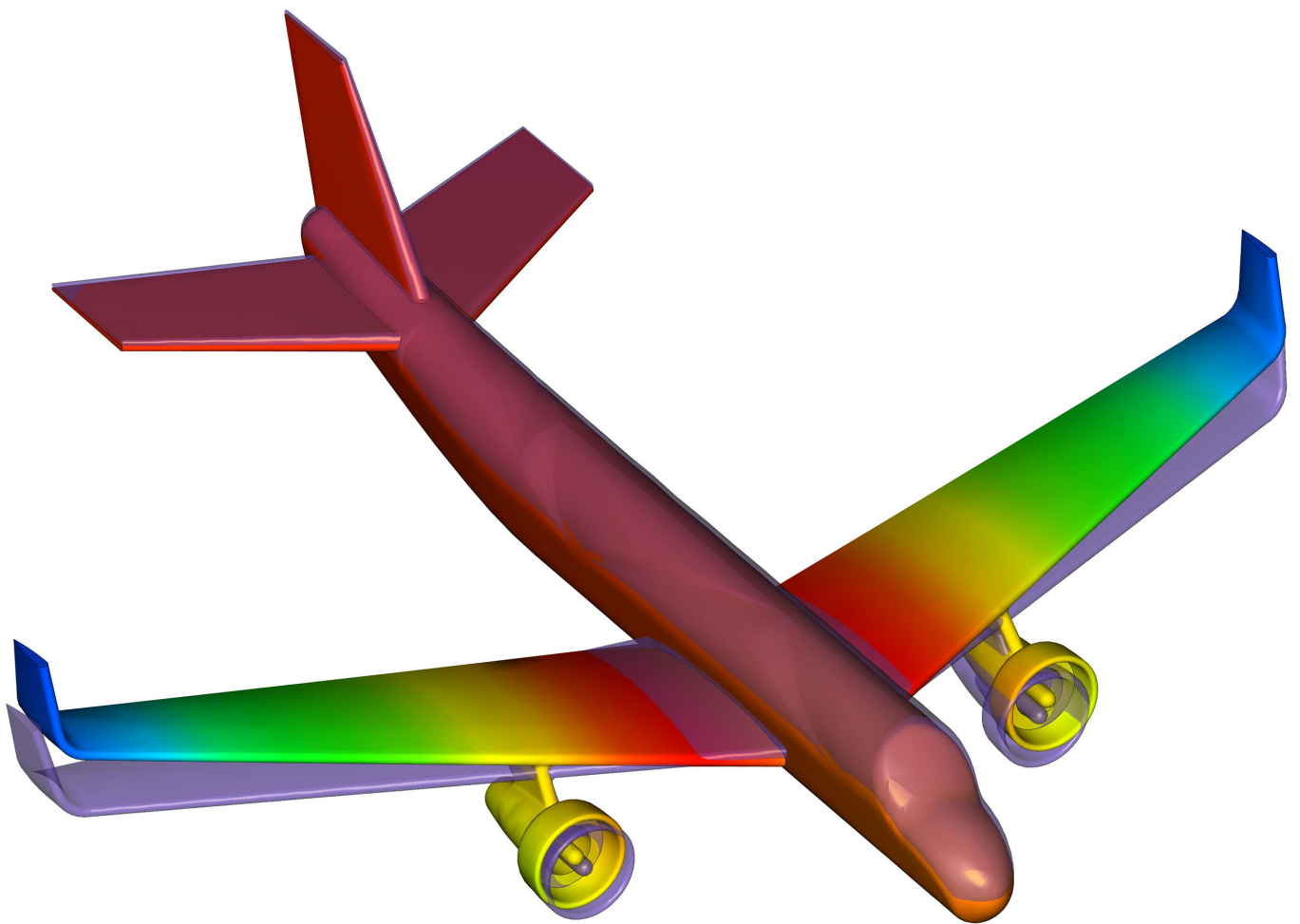


Creo® Simulate 9.0 Tutorial

Structure and Thermal



Roger Toogood, Ph.D.

Visit the following websites to learn more about this book:



[amazon.com](https://www.amazon.com)

[Google books](https://books.google.com)

[BARNES & NOBLE](https://www.barnesandnoble.com)

TABLE OF CONTENTS

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

Chapter 1 - Introduction to FEA

Overview	1 - 1
Finite Element Analysis	1 - 1
Examples of Problems Solved using Creo Simulate	1 - 3
Example #1 : Stress Analysis	1 - 3
Example #2 : Sensitivity Study	1 - 4
Example #3 : Design Optimization	1 - 5
Example #4 : Thermally Induced Stress	1 - 7
FEA User Beware!	1 - 8
Tips for using Creo Simulate	1 - 10
Questions for Review	1 - 11
Exercises	1 - 12

Chapter 2 - Finite Element Analysis with Creo Simulate

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 Creo 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 - 12
Overview of Creo Simulate	2 - 14
Basic Operation	2 - 14
Modes of Operation	2 - 15
TABLE 2-1 - An Overall View of Creo Capability and Function	2 - 15
Types of Models	2 - 16
Types of Elements	2 - 16
Analysis Methods	2 - 16
Convergence Methods	2 - 16
Design Studies	2 - 17
A Brief Note about Units	2 - 18
TABLE 2-2 - Common unit systems in Creo	2 - 18

Files and Directories Produced by Creo	2 - 19
TABLE 2-3 - Some Files Produced by Creo	2 - 20
On-line Documentation	2 - 20
Process Guide	2 - 21
Summary	2 - 21
References	2 - 22
Questions for Review	2 - 23
Exercises	2 - 23

Chapter 3 - Solid Models - Part 1 (Standard Static Analysis)

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 Creo Simulate	3 - 3
Applying the Constraints	3 - 5
Applying the Loads	3 - 7
Specifying the Material	3 - 8
Setting up the Analysis	3 - 10
Running the Analysis	3 - 12
Displaying the Results	3 - 15
Creating Result Window Definitions	3 - 15
Showing the Result Windows	3 - 20
Simulation Features in the Model Tree	3 - 26
Defining and Using Measures	3 - 26
Reporting Measures using Annotations	3 - 29
Using Measures to Monitor and Control Convergence	3 - 30
Exploring the FEA Mesh and AutoGEM	3 - 32
Summary	3 - 37
Questions for Review	3 - 39
Exercises	3 - 40

Chapter 4 - Solid Models - Part 2 (Design Studies, Optimization, AutoGEM Controls, Superposition)

Overview of this Lesson	4 - 1
Standard Design Studies	4 - 2
Creating a Design Variable	4 - 3
Sensitivity Design Studies	4 - 5
Performing a Shape Review	4 - 6
Running the Sensitivity Study	4 - 7
Displaying the Sensitivity Results	4 - 8
Showing the Result Windows	4 - 8
Optimization Design Studies	4 - 10

Creating Design Variables	4 - 10
Important Considerations for the Search Space	4 - 12
Running the Optimization Design Study	4 - 13
What Happens During Optimization?	4 - 13
Optimization Results	4 - 14
Viewing the Optimization History	4 - 15
Considerations for Applying Loads and Constraints	4 - 16
Using Excluded Elements	4 - 21
Superposition and Multiple Load Sets	4 - 25
Creating Multiple Load Sets	4 - 26
Setting the Analysis for Multiple Load Sets	4 - 26
Combining Results for Multiple Load Sets	4 - 27
Summary	4 - 30
Questions for Review	4 - 31
Exercises	4 - 32

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 - 7
Exploring Symmetry	5 - 8
Setting Constraints and Loads	5 - 9
Running the Symmetric Half-Model	5 - 10
Plane Strain Models	5 - 12
The Model	5 - 12
Creating the Creo 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 - 15
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 - 19
Viewing the Results	5 - 19
Summary	5 - 20
Questions for Review	5 - 21
Exercises	5 - 23

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 - 4
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
More 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
Defining Shell Properties	6 - 18
Setting Constraints	6 - 19
Setting a Centrifugal Load	6 - 20
Running the Analysis	6 - 21
View the Results	6 - 21
Modifying the Model with Simulation Features	6 - 22
Running the Modified Model	6 - 24
Pressure Loads on Axisymmetric Shells	6 - 25
Summary	6 - 27
Questions for Review	6 - 27
Exercises	6 - 29

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 - 7
Exploring the Model	7 - 8
Manual Shell Creation (Model #2)	7 - 9
Creating the Geometry	7 - 9
Defining Surface Pairs	7 - 10
Examining the Mesh	7 - 11
Completing the Model	7 - 11
Running the Model	7 - 13
Using Excluded Elements	7 - 16
Mixed Solids and Shells (Model #3)	7 - 20
Creating the Shells	7 - 21
Defining the Constraints	7 - 22
Defining a Bearing Load	7 - 23
Running the Analysis	7 - 24
Reviewing the Results	7 - 25
Exploring the <i>Thin Solid</i> option	7 - 26
Summary	7 - 27
Questions for Review	7 - 28
Exercises	7 - 29

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 - 3
Example #1 - Basic Concepts	8 - 4
The Model	8 - 4
Geometry	8 - 5
Beam Elements	8 - 5
Completing the Model	8 - 6
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 Geometry	8 - 12
Defining Beam Elements	8 - 13
Completing the Model	8 - 14
Constraints	8 - 14
Distributed Loads	8 - 14
Analysis and Results	8 - 17

Result Windows	8 - 17
Beam Releases	8 - 19
Setting Releases	8 - 19
Results with Beam Releases	8 - 20
Example #3 - Frames	8 - 21
Model A - 2D Frame	8 - 21
Model Geometry	8 - 21
Beam Elements	8 - 22
Completing the Model	8 - 23
Analysis and Results	8 - 24
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
Forced Displacement Constraint	8 - 29
Converting a Frame to a Truss	8 - 30
Summary	8 - 31
Questions for Review	8 - 32
Exercises	8 - 33

Chapter 9 - Miscellaneous Topics (Cyclic Symmetry, Modal Analysis, Springs and Masses, Contact Analysis)

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 - 7
Model Geometry	9 - 8
Creating the Elements	9 - 8
Loads and Constraints	9 - 9
Analysis and Results	9 - 10
Defining Measures	9 - 11
Modal Analysis	9 - 12
Setting up the Model	9 - 12
Defining the Modal Analysis	9 - 12
Showing the Mode Shapes	9 - 13
Modeling Interfaces in Assemblies	9 - 15
Using Bonded Surfaces	9 - 17
Creating Contact Regions	9 - 18
Notes for Contact Analysis	9 - 20
Summary	9 - 21
Questions for Review	9 - 22
Exercises	9 - 23

Chapter 10 - Thermal Models (Steady state and transient models; transferring thermal results for stress analysis)

Overview of this Lesson	10 - 1
Overview of Thermal Mode	10 - 1
What can you do with Thermal?	10 - 2
Why use Thermal?	10 - 3
Material Properties	10 - 3
Model Types and Idealizations	10 - 3
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 - 23
Summary	10 - 25
Conclusion	10 - 26
Questions for Review	10 - 28
Exercises	10 - 28