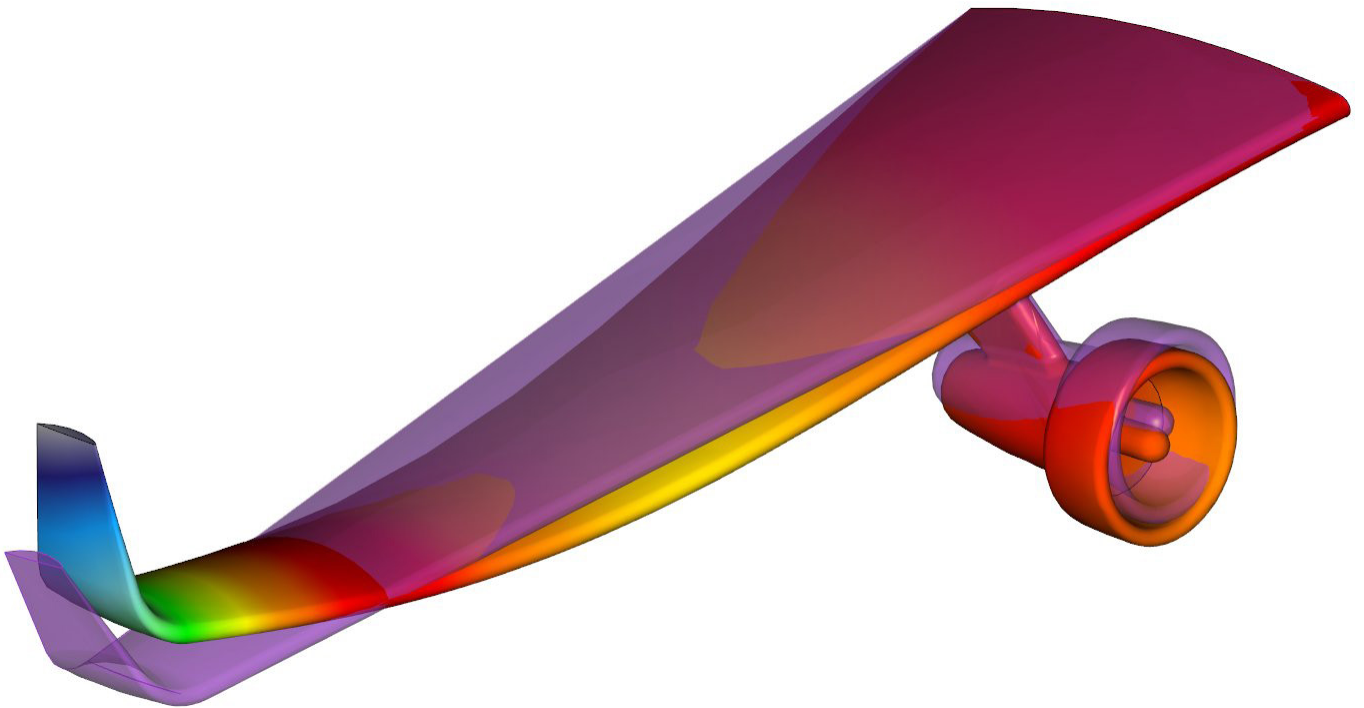


# Creo® Simulate 3.0 Tutorial

Structure and Thermal



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

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 the Tutorials

Overview of this Lesson	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
Table 1-1 Common Mouse Functions	1 - 11
Questions for Review	1 - 11
Exercises	1 - 12

### Chapter 2 - Finite Element Modeling 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 - 14
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 - 21
Process Guide .....	2 - 21
Summary .....	2 - 21
References .....	2 - 22
Questions for Review .....	2 - 23
Exercises .....	2 - 23

### 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 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 - 14
Creating Result Window Definitions .....	3 - 14
Showing the Result Windows .....	3 - 20
Simulation Features in the Model Tree .....	3 - 26
Defining and Using Measures .....	3 - 26
Reporting Measures using <i>Annotations</i> .....	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)

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 - 8
Showing the Result Windows .....	4 - 8
Optimization .....	4 - 10

Creating Design Variables .....	4 - 10
Important Considerations for the Search Space .....	4 - 12
Running the Optimization Design Study .....	4 - 13
Optimization Results .....	4 - 14
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 - 6
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 - 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
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 .....	6 - 22
Running the Modified Model .....	6 - 24
Pressure Loads on Axisymmetric Shells .....	6 - 25
Summary .....	6 - 27
Questions for Review .....	6 - 28
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 Model	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 - 24
Exploring the <i>Thin Solid</i> option	7 - 26
Summary	7 - 27
Questions for Review	7 - 27
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 - 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 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 - 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 - 28
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

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
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
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

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 - 20
Creating the Structure Model .....	10 - 22
Summary .....	10 - 24
Conclusion .....	10 - 25
Questions for Review .....	10 - 27
Exercises .....	10 - 27