Introduction to

Finite Element Analysis Using SOLIDWORKS Simulation 2023

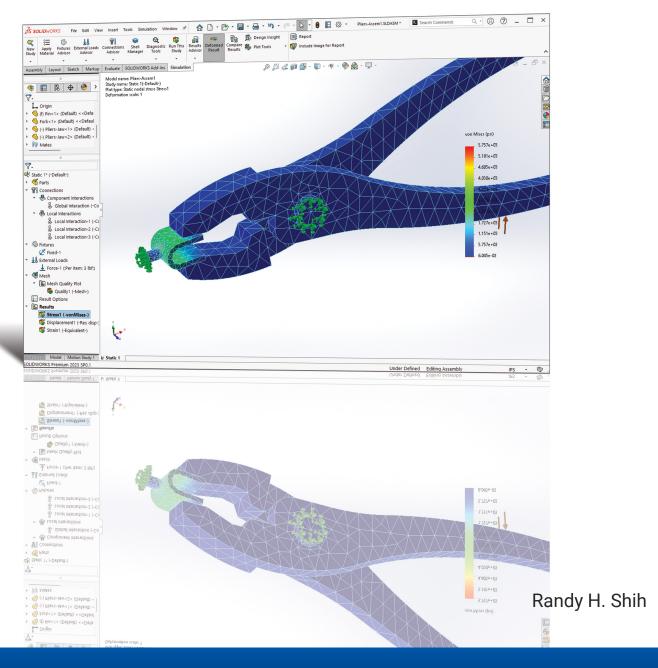












Table of Contents

Preface Acknowledgments	i ii
Introduction	
Introduction Development of Finite Element Analysis FEA Modeling Considerations Types of Finite Elements Finite Element Analysis Procedure Matrix Definitions Getting Started with SOLIDWORKS Starting SOLIDWORKS SOLIDWORKS Screen Layout Menu Bar Menu Bar Menu Bar Pull-down Menus Heads-up View Toolbar Features Toolbar Sketch Toolbar Feature Manager Design Tree Graphics Area Reference Triad Origin Confirmation Corner Graphics Cursor or Crosshairs Message and Status Bar Using the SOLIDWORKS Command Manager Mouse Buttons [Esc] – Canceling Commands SOLIDWORKS Help System	Intro-2 Intro-2 Intro-3 Intro-4 Intro-6 Intro-6 Intro-6 Intro-9 Intro-9 Intro-12 Intro-12 Intro-13 Intro-13 Intro-14 Intro-13 Intro-15 Intro-15 Intro-15 Intro-16 Intro-16 Intro-17 Intro-17 Intro-18 Intro-18 Intro-19 Int
Leaving SOLIDWORKS Create a CAD Files Folder	Intro-19 Intro-19
Chapter 1 The Direct Stiffness Method	
Introduction One-dimensional Truss Element Example 1.1 Example 1.2 Basic Solid Modeling Using SOLIDWORKS The Adjuster Design	1-2 1-3 1-5 1-7 1-10 1-10

Starting SOLIDWORKS Step 1: Create a Rough Sketch Graphics Cursors Geometric Relation Symbols Step 2: Apply/Modify Relations and Dimensions Viewing Functions – Zoom and Pan Delete an Existing Geometry of the Sketch Modify the Dimensions of the Sketch Step 3: Complete the Base Solid Feature Isometric View Rotation of the 3D Model – Rotate View Rotation and Panning – Arrow Keys Dynamic Viewing – Quick Keys 3D Rotation Viewing Tools – Heads-up View Toolbar View Orientation Display Style Orthographic vs. Perspective Customize the Heads-up View Toolbar Step 4-1: Adding an Extruded Boss Feature Step 4-2: Adding an Extruded Cut Feature Step 4-3: Adding another Cut Feature Save the Model Questions Exercises	1-10 1-12 1-12 1-14 1-15 1-17 1-18 1-19 1-20 1-21 1-21 1-23 1-24 1-26 1-26 1-27 1-28 1-28 1-28 1-28 1-35 1-37 1-38 1-39
Chapter 2 Truss Elements in Two-Dimensional Spaces	1-37
Introduction Truss Elements in Two-Dimensional Spaces Coordinate Transformation Example 2.1 Solution Global Stiffness Matrix Example 2.2 Solution Questions Exercises	2-2 2-2 2-5 2-9 2-10 2-13 2-13 2-19 2-20
Chapter 3 2D Trusses in MS Excel and Truss Solver	
Direct Stiffness Matrix Method using Excel Example 3.1	3-2 3-2

5-23

Create the FEA Mesh and Run the Solver

Viewing the Stress results Viewing the Internal Loads of All members Viewing the Reaction Forces at the supports Questions Exercises	5-24 5-26 5-27 5-28 5-29
Chapter 6 Three-Dimensional Truss Analysis	
Three-Dimensional Coordinate Transformation Matrix Stiffness Matrix Degrees of Freedom Problem Statement Preliminary Analysis Start SOLIDWORKS Units Setup Create the CAD Model – Structural Member Approach Create a New Weldment Profile in SOLIDWORKS Create Structural Members using the New Profile Editing the Dimensions of the New Profile Activate the SOLIDWORKS Simulation Module Setting Up the Truss Elements Assign the Element Material Property Applying Boundary Conditions - Constraints Applying the External Load Create the FEA Mesh and Run the Solver Using the Probe Option to View Individual Stress Viewing the Internal Loads of All Members Questions Exercises	6-2 6-3 6-3 6-5 6-5 6-7 6-8 6-9 6-12 6-17 6-19 6-20 6-22 6-23 6-24 6-25 6-27 6-28 6-29 6-30 6-31
Chapter 7 Basic Beam Analysis	
Introduction Modeling Considerations Problem Statement Preliminary Analysis Start SOLIDWORKS Units Setup Create the CAD Model – Structural Member Approach Create a Rectangular Weldment Profile Create Structural Members Using the New Profile Adjust the Orientation of the Profile	7-2 7-2 7-3 7-3 7-6 7-7 7-8 7-10 7-14 7-15

Create a Circular Weldment Profile

vii

9-9

Create Structural Members using the New Profile Add a Datum Point for the Concentrated Load Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions - Constraints Apply the Concentrated Point Load Create the FEA Mesh and Run the Solver Viewing the Internal Loads of All members Shear and Moment Diagrams Questions Exercises	9-13 9-14 9-16 9-18 9-19 9-22 9-24 9-25 9-26 9-28 9-29
Chapter 10 Two-Dimensional Surface Analysis	
Introduction Problem Statement Preliminary Analysis Maximum Normal Stress Maximum Displacement Geometric Considerations of Finite Elements Start SOLIDWORKS Create the CAD Model Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions - Constraints Apply the External Load H-Element versus P-Element Create the first FEA Mesh—Coarse Mesh Run the Solver Refinement of the FEA Mesh—Global Element Size 0.10 Refinement of the FEA Mesh—Global Element Size 0.03 Refinement of the FEA Mesh—Global Element Size 0.02 Comparison of Results Questions Exercises	10-2 10-3 10-3 10-3 10-4 10-5 10-6 10-7 10-10 10-13 10-14 10-17 10-18 10-19 10-21 10-23 10-25 10-27 10-28 10-29 10-30 10-31
Chapter 11 Three-Dimensional Solid Elements	
Introduction Problem Statement Preliminary Analysis	11-2 11-3 11-4

Start SOLIDWORKS	11-7
Create a CAD Model in SOLIDWORKS	11-8
> Define the Sweep Path	11-8
> Define the Sweep Section	11-10
Create the Swept Feature	11-12
> Create a Cut Feature	11-13
Activate the SOLIDWORKS Simulation Module	11-15
Assign the Element Material Property	11-17
Apply Boundary Conditions – Constraints	11-18
Apply the External Load to the system	11-19
Create the first FEA Mesh – Coarse Mesh	11-20
Run the Solver	11-22
Refinement of the FEA Mesh – Global Element Size 0.10	11-24
Refinement of the FEA Mesh – Mesh Control Option	11-26
Refinement of the FEA Mesh – Automatic Transition	11-29
Comparison of Results	11-31
Questions	11-32
Exercises	11-33
Chapter 12	
Chapter 12 2D Avisymmetric and 2D Thin Shall Analysis	
2D Axisymmetric and 3D Thin Shell Analyses	
Introduction	12-2
Introduction Problem Statement	12-2 12-4
Problem Statement	
	12-4
Problem Statement Preliminary Analysis	12-4 12-4
Problem Statement Preliminary Analysis Start SOLIDWORKS	12-4 12-4 12-6
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS	12-4 12-4 12-6 12-7
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module	12-4 12-4 12-6 12-7 12-9
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module Assign the Element Material Property	12-4 12-4 12-6 12-7 12-9 12-12
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions – Constraints	12-4 12-4 12-6 12-7 12-9 12-12 12-13
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results	12-4 12-4 12-6 12-7 12-9 12-12 12-13 12-14 12-15 12-16
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results Refinement of the FEA Mesh – Global Element Size 5.0	12-4 12-4 12-6 12-7 12-9 12-12 12-13 12-14 12-15 12-16 12-17
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results Refinement of the FEA Mesh – Global Element Size 5.0 Start a New 3D Surface Model	12-4 12-4 12-6 12-7 12-9 12-12 12-13 12-14 12-15 12-16 12-17 12-18
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results Refinement of the FEA Mesh – Global Element Size 5.0 Start a New 3D Surface Model Start a New FEA Study	12-4 12-4 12-6 12-7 12-9 12-12 12-13 12-14 12-15 12-16 12-17 12-18 12-21
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results Refinement of the FEA Mesh – Global Element Size 5.0 Start a New 3D Surface Model Start a New FEA Study Completing the Definition of the Surface Model	12-4 12-4 12-6 12-7 12-9 12-12 12-13 12-14 12-15 12-16 12-17 12-18 12-21 12-22
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results Refinement of the FEA Mesh – Global Element Size 5.0 Start a New 3D Surface Model Start a New FEA Study Completing the Definition of the Surface Model Assign the Element Material Property	12-4 12-4 12-6 12-7 12-9 12-12 12-13 12-14 12-15 12-16 12-17 12-18 12-21 12-22 12-23
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results Refinement of the FEA Mesh – Global Element Size 5.0 Start a New 3D Surface Model Start a New FEA Study Completing the Definition of the Surface Model Assign the Element Material Property Apply Boundary Conditions – Constraints	12-4 12-4 12-6 12-7 12-9 12-12 12-13 12-14 12-15 12-16 12-17 12-18 12-21 12-22 12-23 12-24
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results Refinement of the FEA Mesh – Global Element Size 5.0 Start a New 3D Surface Model Start a New FEA Study Completing the Definition of the Surface Model Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System	12-4 12-4 12-6 12-7 12-9 12-12 12-13 12-14 12-15 12-16 12-17 12-18 12-21 12-22 12-23 12-24 12-28
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results Refinement of the FEA Mesh – Global Element Size 5.0 Start a New 3D Surface Model Start a New FEA Study Completing the Definition of the Surface Model Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh	12-4 12-4 12-6 12-7 12-9 12-12 12-13 12-14 12-15 12-16 12-17 12-18 12-21 12-22 12-23 12-24 12-28 12-29
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results Refinement of the FEA Mesh – Global Element Size 5.0 Start a New 3D Surface Model Start a New FEA Study Completing the Definition of the Surface Model Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results	12-4 12-4 12-6 12-7 12-9 12-12 12-13 12-14 12-15 12-16 12-17 12-18 12-21 12-22 12-23 12-24 12-28 12-29 12-30
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results Refinement of the FEA Mesh – Global Element Size 5.0 Start a New 3D Surface Model Start a New FEA Study Completing the Definition of the Surface Model Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results Refinement of the FEA Mesh – Global Element Size 10.0	12-4 12-4 12-6 12-7 12-9 12-12 12-13 12-14 12-15 12-16 12-17 12-18 12-21 12-22 12-23 12-24 12-28 12-29 12-30 12-31
Problem Statement Preliminary Analysis Start SOLIDWORKS Create a 3D Solid Model in SOLIDWORKS Activate the SOLIDWORKS Simulation Module Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results Refinement of the FEA Mesh – Global Element Size 5.0 Start a New 3D Surface Model Start a New FEA Study Completing the Definition of the Surface Model Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results	12-4 12-4 12-6 12-7 12-9 12-12 12-13 12-14 12-15 12-16 12-17 12-18 12-21 12-22 12-23 12-24 12-28 12-29 12-30

Assign the Element Material Property Apply Boundary Conditions – Constraints Apply the Pressure to the System Create the first FEA Mesh – Coarse Mesh Run the Solver and View the Results Refinement of the FEA Mesh – Global Element Size 12.5 Notes on FEA Linear Static Analyses Questions Exercises	12-36 12-37 12-39 12-40 12-41 12-42 12-43 12-44 12-45
Chapter 13 FEA Static Contact Analysis	
Introduction	13-2
Problem Statement	13-3
Parts	13-4
(1) Pliers-Jaw	13-4
(2) Pin	13-6
(3) Fork	13-6
Start SOLIDWORKS	13-8
Document Properties	13-8
Insert the First Component	13-9
Insert the Second Component	13-10
Assembly Mates	13-11
Insert the Third Component	13-14
Insert the Upper Jaw Component	13-16
Identifying Coincident Surfaces in the Model	13-19
Activate the SOLIDWORKS Simulation Module	13-20
Assign the Element Material Property	13-22
Apply Boundary Conditions – Constraints	13-23
Apply the External Load on the Handles	13-24
Global Contact Settings	13-25
Set up Specific Local Surfaces Interaction	13-26
Set up another Surface Interaction set on the PIN part	13-28
SOLIDWORKS Curvature-Based Mesh	13-30
Create the FEA Mesh	13-31
Run the Solver and View the Results	13-32
Use the Animate Option	13-34
Refinement of the FEA Mesh – Apply Mesh Control	13-35
Use the Section Clipping Option	13-37
Use the Iso Clipping Option	13-38
Set up a Contact Pressure Plot	13-39
Questions	13-42
Exercises	13-43

Chapter 14 Dynamic Modal Analysis

Introduction	14-2
Problem Statement	14-3
Preliminary Analysis	14-3
The Cantilever Beam Modal Analysis Program	14-6
Start SOLIDWORKS	14-9
Create the CAD Model	14-10
Activate the SOLIDWORKS Simulation Module	14-12
Assign the Element Material Property	14-14
Apply Boundary Conditions – Constraints	14-15
Create the first FEA Mesh	14-16
Viewing the Results	14-18
Refinement of the FEA Mesh – Global Element Size 0.15	14-21
Add an Additional Mass to the System	14-23
One-Dimensional Beam Frequency Analysis	14-27
Conclusions	14-28
Questions	14-29
Exercises	14-30

Appendix

Index