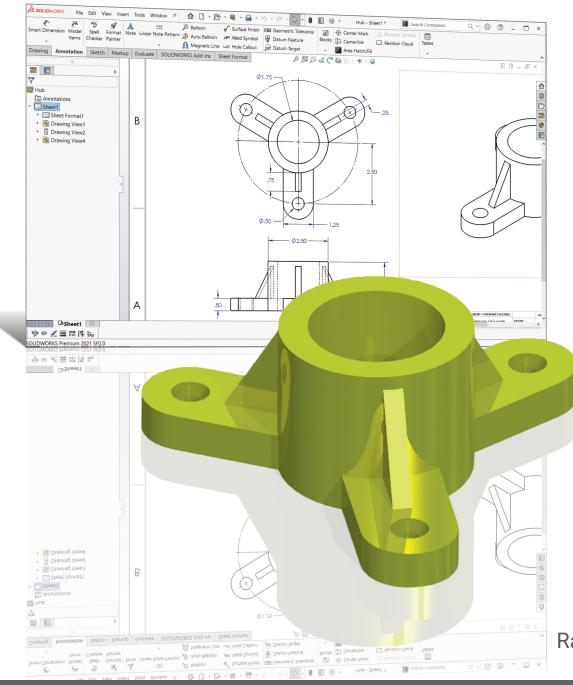
## SOLIDWORKS 2021 and Engineering Graphics

An Integrated Approach



Randy H. Shih

## Visit the following websites to learn more about this book:









## **Table of Contents**

Preface	i
Acknowledgments	ii
Table of Contents	iii
Certified SOLIDWORKS Associate Exam Overview	XV
Tips about Taking the SOLIDWORKS Certified Associate Examination	xxi
Chapter 1	
Introduction	
Introduction	1-2
Drawing in CAD Systems	1-4
Development of Computer Geometric Modeling	1-4
Feature-Based Parametric Modeling	1-8
Getting Started with SOLIDWORKS	1-9
Starting SOLIDWORKS	1-9
SOLIDWORKS Screen Layout	1-12
Menu Bar	1-12
Menu Bar Pull-down Menus	1-13
Heads-up View Toolbar	1-13
Features Toolbar	1-13
Sketch Toolbar	1-13
Feature Manager-Design Tree/Property Manager	1-14
Configuration Manager/DimXpert Manager/Display Manager	1-14
Graphics Area	1-15
Reference Triad	1-15
Origin	1-15
Confirmation Corner	1-15
Graphics Cursor or Crosshairs	1-15
Message and Status Bar	1-15
Using the SOLIDWORKS Command Manager	1-16
Mouse Buttons	1-17
[Esc] - Canceling Commands	1-17
SOLIDWORKS Help System	1-18
Leaving SOLIDWORKS	1-18
Creating a CAD File Folder	1-19
Chapter 2	
Parametric Modeling Fundamentals	
Introduction	2-3
The Adjuster Design	2-4
Starting SOLIDWORKS	2-4
e	2- <del>4</del> 2-5
SOLIDWORKS Part Modeling Window Layout	2-3 2-7
Step 1: Determine/Set up the Base Solid Feature	Z-1

Sketching Plane – It is an XY CRT, but an XYZ world	2-7
Creating Rough Sketches	2-9
Step 2: Creating a Rough Sketch	2-10
Graphics Cursors	2-10
Geometric Relation Symbols	2-12
Step 3: Apply/Modify Relations and Dimensions	2-13
Viewing Functions – Zoom and Pan	2-15
Delete an Existing Geometry of the Sketch	2-16
Modifying the Dimensions of the Sketch	2-17
Step 4: Completing the Base Solid Feature	2-18
Isometric View	2-19
Rotation of the 3-D Model – Rotate View	2-19
Rotation and Panning – Arrow keys	2-21
Dynamic Viewing – Quick Keys	2-22
3D Rotation	2-24
Viewing Tools – Heads-up View Toolbar	2-24
View Orientation	2-25
Display Style	2-26
Orthographic vs. Perspective	2-26
Customizing the Heads-up View Toolbar	2-26
Step 5-1: Adding an Extruded Feature	2-27
Step 5-2: Adding a Cut Feature	2-31
Step 5-3: Adding another Cut Feature	2-33
Save the Model	2-35
Questions	2-36
Exercises	2-37
Chapter 3	
Constructive Solid Geometry Concepts	
Introduction	3-3
Binary Tree	3-4
The Locator Design	3-5
Modeling Strategy – CSG Binary Tree	3-6
Starting SOLIDWORKS and Activating the Command Manager	3-7
GRID and SNAP Intervals Setup	3-9
Base Feature	3-10
Repositioning Dimensions	3-12
Completing the Base Solid Feature	3-13
Creating the Next Solid Feature	3-14
Creating an Extruded Cut Feature	3-17
Creating a Hole with the Hole Wizard	3-20
Creating a Rectangular Extruded Cut Feature	3-23
Using the View Selector	3-25
Questions	3-27
Exercises	3-28

Table of Contents

Chapter 4	
Geometric	<b>Constructions</b>

Geometric Constructions	4-3
Geometric Constructions - Classical Methods	4-4
• Bisection of a Line or Arc	4-4
• Bisection of an Angle	4-5
• Transfer of an Angle	4-6
• Dividing a Given Line into a Number of Equal Parts	4-7
• Circle through Three Points	4-8
• A Line Tangent to a Circle	4-9
• Line Tangent to a circle from a Given Point	4-10
• Circle of a Given Radius Tangent to Two Given Lines	4-11
• Circle of a Given Radius Tangent to an Arc and a Line	4-12
• Circle of a Given Radius Tangent to Two Arcs	4-13
Starting SOLIDWORKS	4-14
Geometric Construction – CAD Method	4-16
• Bisection of a Line or Arc	4-16
Dimensions and Relations	4-18
Geometric Symbols available in parametric sketching	4-19
• Bisection of an Angle	4-20
• Dividing a Given Line into a Number of Equal Parts	4-22
• Circle through Three Points	4-29
• Line Tangent to a circle from a Given Point	4-30
• Circle of a Given Radius Tangent to Two Given Lines	4-31
Adding Geometric Relations and Fully Defined Geometry	4-34
Starting SOLIDWORKS	4-34
Over-Defining and Driven Dimensions	4-41
Deleting Existing Relations	4-42
Using the Fully Define Sketch Tool	4-43
Adding Additional Geometry	4-44
Adding New Equations	4-49
Questions	4-51
Exercises	4-52
Chapter 5	
Feature Design Tree	
Introduction	5-3
Starting SOLIDWORKS	5-4
Creating a User-Defined Part Template	5-5
The Saddle Bracket Design	5-9
Modeling Strategy	5-10
The SOLIDWORKS Feature Manager Design Tree	5-11
Creating the Base Feature	5-11
Adding the Second Solid Feature	5-14

Creating a 2D Sketch	5-15
Renaming the Part Features	5-17
Adjusting the Width of the Base Feature	5-18
Adding a Cut Feature	5-19
Creating a Rectangular Extruded Cut Feature	5-22
History-Based Part Modifications	5-23
A Design Change	5-24
Feature Manager Design Tree Views	5-26
Questions	5-28
Exercises	5-29
Chapter 6 Geometric Construction Tools	
	( )
Introduction The Contest Project	6-3
The Gasket Design	6-3
Modeling Strategy	6-4
Starting SOLIDWORKS Creating a 2D Sketch	6-5 6-6
Editing the Sketch by Dragging the Entities	6-8
Adding Additional Relations	6-10
Using the <i>Trim</i> and <i>Extend</i> Commands	6-11
Adding Dimensions with the Fully Define Sketch Tool	6-14
Fully Defined Geometry	6-16
Creating Fillets and Completing the Sketch	6-17
Profile Sketch	6-18
Redefining the Sketch and Profile using Contour Selection	6-19
Create an OFFSET Extruded Cut Feature	6-23
Questions	6-27
Exercises	6-28
Chapter 7 Orthographic Projections and Multiview Const	ructions
Introduction	7-3
Basic Principles of Projection	7-4
Orthographic Projection	7-4
Multiview Orthographic Projection	7-5
First-Angle Projection	7-6
Rotation of the Horizontal and Profile Planes	7-7
The 3D Adjuster Model and 1 <sup>st</sup> angle projection	7-8
General Procedure: 1 <sup>St</sup> Angle Orthographic Projection	7-9
Example 2: 1 <sup>St</sup> Angle Orthographic Projection	7-10
Chapter 7 - 1 <sup>St</sup> Angle Orthographic Sketching Exercise 1	7-11
Chapter 7 - 1 <sup>St</sup> Angle Orthographic Sketching Exercise 2	7-13
Chapter 7 - 1 <sup>St</sup> Angle Orthographic Sketching Exercise 3	7-15
Chapter 7 - 1 <sup>St</sup> Angle Orthographic Sketching Exercise 4	7-17

Chapter 7 - 1 <sup>St</sup> Angle Orthographic Sketching Exercise 5	7-19
Chapter 7 - 1 <sup>St</sup> Angle Orthographic Sketching Exercise 6	7-21
Third-Angle Projection	7-23
Rotation of the Horizontal and Profile Planes	7-24
The 3D Adjuster Model and 3 <sup>rd</sup> angle projection	7-25
The Glass Box and the Six Principal Views	7-26
General Procedure: 3 <sup>rd</sup> Angle Orthographic Projection	7-28
Example 2: 3 <sup>rd</sup> Angle Orthographic Projection	7-29
Example 3: 3 <sup>rd</sup> Angle Orthographic Projection	7-30
Chapter 7 - 3 <sup>rd</sup> Angle Orthographic Sketching Exercise 1	7-31
Chapter 7 - 3 <sup>rd</sup> Angle Orthographic Sketching Exercise 2	7-33
Chapter 7 - 3 <sup>rd</sup> Angle Orthographic Sketching Exercise 3	7-35
Chapter 7 - 3 <sup>rd</sup> Angle Orthographic Sketching Exercise 4	7-37
Chapter 7 - 3 <sup>rd</sup> Angle Orthographic Sketching Exercise 5	7-39
Chapter 7 - 3 <sup>rd</sup> Angle Orthographic Sketching Exercise 6	7 <b>-</b> 39
Alphabet of Lines	7-41
Precedence of Lines	7-45
	7-43 7-46
The U-Bracket Design Starting SOLIDWORKS	7-46 7-46
Applying the BORN Technique	7-47
Creating the 2D Sketch of the Base Feature	7-48
Creating the First Extrude Feature	7-55
The Implied Parent/Child Relationships	7-55
Creating the Second Solid Feature	7-56
Creating the First Extruded Cut Feature	7-59
Creating the Second Extruded Cut Feature	7-60
Examining the Parent/Child Relationships	7-62
Modify a Parent Dimension	7-63
A Design Change	7-64
Feature Suppression	7-65
A Different Approach to the CENTER_DRILL Feature	7-66
Suppress the Rect_Cut Feature	7-67
Creating a Circular Extruded Cut Feature	7-68
A Flexible Design Approach	7-70
Drawings from Parts and Associative Functionality	7-71
Drawing Mode	7-72
Setting Document Properties	7-74
Setting Sheet Properties using the Pre-Defined Sheet Formats	7-75
Creating Three Standard Views	7-76
Repositioning Views	7-76
Adding a New Sheet	7-78
Adding a Base View	7-79
Adding an Isometric View using the View Palette	7-82
Adjusting the View Scale	7-83
Questions	7-85
Exercises	7-86

Chapter 8		
Dimensioning	and	Notes

Introduction	8-3
Dimensioning Standards and Basic Terminology	8-4
Selection and Placement of Dimensions and Notes	8-5
Machined Holes	8-12
Baseline and Chain Dimensioning	8-15
Dimensioning and Tolerance Accumulation	8-16
(1) Tolerance Accumulation - Baseline Dimensioning	8-17
(2) Tolerance Accumulation - Chain Dimensioning	8-18
(3) Avoid Tolerance Accumulation - Dimensioning Features	8-19
Dimensioning Tools in SOLIDWORKS	8-20
The U-Bracket Design	8-20
Starting SOLIDWORKS	8-21
Display Feature Dimensions	8-22
Repositioning, Appearance, and Hiding of Feature Dimensions	8-23
Adding Additional Dimensions – Reference Dimensions	8-25
Tangent Edge Display	8-27
Adding Center Marks, Center Lines, and Sketch Objects	8-27
Edit Sheet vs. Edit Sheet Format	8-32
Modify the Title Block	8-32
Property Links	8-35
Associative Functionality – Modifying Feature Dimensions	8-39
Saving the Drawing File	8-42
Create a B size Drawing Template	8-42
Questions	8-45
Exercises	8-46
Chapter 9 Tolorancing and Fits	
Tolerancing and Fits	0.2
Precision and Tolerance	9-2
Methods of Specifying Tolerances – English System	9-3
Nomenclature	9-4
Example 9.1	9-5
Fits between Mating parts	9-6
Selective Assembly	9-7
Basic Hole and Basic Shaft Systems	9-7
American National Standard Limits and Fits – Inches	9-8
Example 9.2 Basic Hole System	9-13
Example 9.3 Basic Hole System	9-14
Example 9.4 Basic Shaft System	9-15
Example 9.5 Basic Shaft System	9-16
Tolerancing – Metric System	9-17
Metric Tolerances and Fits Designation	9-18
Preferred ISO Metric Fits	9-19

	Table of Contents
Example 9.6 Metric Hole Basis System Example 9.7 Shaft Basis System Updating the U-Bracket Drawing Determining the Tolerances Required Questions	9-20 9-21 9-22 9-23 9-25
Chapter 10 Pictorials and Sketching	9-26
Engineering Drawings, Pictorials and Sketching Isometric Sketching Chapter 10 - Isometric Sketching Exercise 1 Chapter 10 - Isometric Sketching Exercise 2 Chapter 10 - Isometric Sketching Exercise 3 Chapter 10 - Isometric Sketching Exercise 4 Chapter 10 - Isometric Sketching Exercise 5 Chapter 10 - Isometric Sketching Exercise 6 Chapter 10 - Isometric Sketching Exercise 7 Chapter 10 - Isometric Sketching Exercise 8 Chapter 10 - Isometric Sketching Exercise 9 Chapter 10 - Isometric Sketching Exercise 9 Chapter 10 - Oblique Sketching Exercise 10 Oblique Sketching Chapter 10 - Oblique Sketching Exercise 2 Chapter 10 - Oblique Sketching Exercise 3 Chapter 10 - Oblique Sketching Exercise 4 Chapter 10 - Oblique Sketching Exercise 4 Chapter 10 - Oblique Sketching Exercise 5 Chapter 10 - Oblique Sketching Exercise 6 Perspective Sketching One-Point Perspective Two-Point Perspective Chapter 10 - Perspective Sketching Exercise 2 Chapter 10 - Perspective Sketching Exercise 3 Chapter 10 - Perspective Sketching Exercise 3 Chapter 10 - Perspective Sketching Exercise 4 Chapter 10 - Perspective Sketching Exercise 5 Chapter 10 - Perspective Sketching Exercise 4 Chapter 10 - Perspective Sketching Exercise 5 Chapter 10 - Perspective Sketching Exercise 5 Chapter 10 - Perspective Sketching Exercise 5 Chapter 10 - Perspective Sketching Exercise 6 Questions Exercises	10-2 10-7 10-9 10-11 10-13 10-15 10-17 10-19 10-21 10-23 10-25 10-27 10-29 10-31 10-33 10-35 10-37 10-39 10-41 10-43 10-44 10-45 10-47 10-49 10-51 10-53 10-57 10-59 10-60
Chapter 11 Section Views & Symmetrical Features in Desig Introduction	
General Rules of Section Views	11-5

ix

Section Drawing Types	11-6
• Full Section	11-6
Half Section	11-6
Offset Section	11-7
Broken-Out Section	11-7
Aligned Section	11-8
• Half Views	11-8
• Thin Sections	11-8
Revolved Section	11-9
Removed Section	11-9
Conventional Breaks	11-10
Ribs and Webs in Sections	11-10
Parts Not Sectioned	11-10
Section Views in SOLIDWORKS	11-11
A Revolved Design: PULLEY	11-11
Modeling Strategy - A Revolved Design	11-12
Starting SOLIDWORKS	11-13
Creating the Base Feature	11-13
Creating the Revolved Feature	11-17
Mirroring Features	11-17
Creating an Extruded Cut Feature using Construction Geometry	11-19
Circular Pattern	11-24
Drawing Mode – Defining a New Border and Title Block	11-26
Create a New Drawing Template	11-30
Creating Views	11-31
Retrieve Dimensions – Model Items Command	11-34
Save the Drawing File	11-35
Associative Functionality – A Design Change	11-36
Adding Centerlines to the Pattern Feature	11-38
Completing the Drawing	11-40
Additional Title Blocks	11-43
Questions	11-45
Exercises	11-46
Chapter 12 Auxiliany Views and Beforence Geometry	
Auxiliary Views and Reference Geometry	
Introduction	12-3
Normal View of an Inclined Surface	12-4
Construction Method I – Folding Line Method	12-6
Construction Method II – Reference Plane Method	12-8
Partial Views	12-10
Reference Geometry in SOLIDWORKS	12-11
Auxiliary Views in 2D Drawings	12-11
The Rod-Guide Design	12-11
Modeling Strategy	12-12

Table of Contents xi

Starting SOLIDWORKS	12-13
Applying the BORN Technique	12-13
Creating the Base Feature	12-14
Creating an Angled Reference Plane	12-16
Creating an Extruded Feature on the Reference Plane	12-19
Using the Convert Entities Option	12-19
Completing the Solid Feature	12-25
Creating an Offset Reference Plane	12-26
Creating another Extruded Feature using the Reference Plane	12-27
Starting a New 2D Drawing and Adding a Base View	12-29
Creating an Auxiliary View	12-30
Displaying Feature Dimensions	12-32
Adjusting the View Scale	12-34
Repositioning, Appearance, and Hiding of Feature Dimensions	12-34
Tangent Edge Display	12-37
Adding Center Marks and Center Lines	12-37
Controlling the View and Sheet Scales	12-40
Completing the Drawing Sheet	12-41
Editing the Isometric view	12-42
Adding a General Note	12-42
Questions	12-44
Exercises	12-45
Chapter 13	
Introduction to 3D Printing	
What is 3D Printing	13-2
Development of 3D Printing Technologies	13-3
Primary types of 3D Printing processes	13-6
Stereolithography	13-6
Fused Deposition Modeling & Fused Filament Fabrication	13-7
Laser Sintering / Laser Melting	13-8
Primary 3D Printing Materials for FDM and FFF	13-9
From 3D model to 3D printed Part	13-11
Starting SOLIDWORKS	13-12
SOLIDWORKS Print3D Command	13-13
Using the 3D Printing software to create the 3D Print	13-18
Questions	13-26
Chapter 14	
Threads and Fasteners	
Introduction	14-2
Screw-Thread Terminology	14-3
Thread Forms	14-5
Thread Representations	14-6

• Detailed Representation	14-7
• Schematic Representation	14-8
• Simplified Representation	14-9
Thread Specification – English Units	14-10
Unified Thread Series	14-11
Thread Fits	14-12
Thread Specification – Metric	14-12
Thread Notes Examples	14-13
Specifying Fasteners	14-14
Commonly Used Fasteners	14-15
Drawing Standard Bolts	14-17
Bolt and Screw Clearances	14-17
Fasteners using SOLIDWORKS' Design Library	14-18
ANSI Inch - Machine Screw	14-18
ANSI Metric - Machine Screw	14-20
Questions	14-22
Chapter 15	
Assembly Modeling and Working Drawings	
General Engineering Design Process	15-3
Working Drawings	15-4
Detail Drawings	15-4
Assembly Drawings	15-5
Bill of Materials (BOM) and Parts List	15-5
Drawing Sizes	15-6
Drawing Sheet Borders and Revisions Block	15-6
Title Blocks	15-7
Working Drawings with SOLIDWORKS	15-8
Assembly Modeling Methodology	15-8
The Shaft Support Assembly	15-9
Parts	15-9
Creating the Collar with the Chamfer Command	15-9
Creating the Bearing and Base-Plate	15-11
Creating the Cap-Screw	15-12
Starting SOLIDWORKS	15-13
Document Properties	15-13
Insert the First Component	15-14
Insert the Second Component	15-15
Degrees of Freedom	15-16
Assembly Mates	15-16
Apply the First Assembly Mate	15-18
Apply a Second Mate	15-19
Constrained Move	15-21
Apply a Third Mate	15-22
Inserting the Third Component	15-24

Applying Concentric and Coincident Mates	15-24
Assemble the Cap-Screws using SmartMates	15-26
Exploded View of the Assembly	15-30
Save the Assembly Model	15-32
Editing the Components	15-32
Set up a Drawing of the Assembly Model	15-34
Creating a Bill of Materials	15-35
Editing the Bill of Materials	15-37
Completing the Assembly Drawing	15-41
Exporting the Bill of Materials	15-43
Questions	15-44
Exercises	15-45
Chapter 16	
CSWA Exam Preparation	
Tips about Taking the Certified SOLIDWORKS Associate Examination	16-3
Introduction	
The Part Problem	
Strategy for Aligning the Part to the Default Axis System	
Creating the Base Feature	
Creating a New View Orientation	
Create Reference Planes and a Reference Axis	
Selecting the Material and Viewing the Mass Properties	
The Assembly Problem	
Creating the Parts	
Creating the Assembly	16-21
Creating a Reference Coordinate System	
View the Mass Properties	16-29
Questions	16-31
Exercises	16-32
Appendix	
A. Running and Sliding Fits – American National Standard	
B. Metric Limits and Fits	
C. UNIFIED NATIONAL THREAD FORM	
D. METRIC THREAD FORM	
E. FASTENERS (INCH SERIES)	
F. METRIC FASTENERS	
G. BOLT AND SCREW CLEARANCE HOLES	
H. REFERENCES	

## Index