

# SOLIDWORKS®

## **Advanced Part Modeling**

Dassault Systèmes SolidWorks Corporation  
175 Wyman Street  
Waltham, Massachusetts 02451 USA

© 1995-2019, Dassault Systemes SolidWorks Corporation, a Dassault Systèmes SE company, 175 Wyman Street, Waltham, Mass. 02451 USA. All Rights Reserved.

The information and the software discussed in this document are subject to change without notice and are not commitments by Dassault Systemes SolidWorks Corporation (DS SolidWorks).

No material may be reproduced or transmitted in any form or by any means, electronically or manually, for any purpose without the express written permission of DS SolidWorks.

The software discussed in this document is furnished under a license and may be used or copied only in accordance with the terms of the license. All warranties given by DS SolidWorks as to the software and documentation are set forth in the license agreement, and nothing stated in, or implied by, this document or its contents shall be considered or deemed a modification or amendment of any terms, including warranties, in the license agreement.

#### Patent Notices

SOLIDWORKS® 3D mechanical CAD and/or Simulation software is protected by U.S. Patents 6,611,725; 6,844,877; 6,898,560; 6,906,712; 7,079,990; 7,477,262; 7,558,705; 7,571,079; 7,590,497; 7,643,027; 7,672,822; 7,688,318; 7,694,238; 7,853,940; 8,305,376; 8,581,902; 8,817,028; 8,910,078; 9,129,083; 9,153,072; 9,262,863; 9,465,894; 9,646,412; 9,870,436; 10,055,083; 10,073,600; 10,235,493 and foreign patents, (e.g., EP 1,116,190 B1 and JP 3,517,643).

eDrawings® software is protected by U.S. Patent 7,184,044; U.S. Patent 7,502,027; and Canadian Patent 2,318,706.

U.S. and foreign patents pending.

#### Trademarks and Product Names for SOLIDWORKS Products and Services

SOLIDWORKS, 3D ContentCentral, 3D PartStream.NET, eDrawings, and the eDrawings logo are registered trademarks and FeatureManager is a jointly owned registered trademark of DS SolidWorks.

CircuitWorks, FloXpress, PhotoView 360, and TolAnalyst are trademarks of DS SolidWorks.

FeatureWorks is a registered trademark of HCL Technologies Ltd.

SOLIDWORKS 2020, SOLIDWORKS Standard, SOLIDWORKS Professional, SOLIDWORKS Premium, SOLIDWORKS PDM Professional, SOLIDWORKS PDM Standard, SOLIDWORKS Simulation Standard, SOLIDWORKS Simulation Professional, SOLIDWORKS Simulation Premium, SOLIDWORKS Flow Simulation, SOLIDWORKS CAM, SOLIDWORKS Manage, eDrawings Viewer, eDrawings Professional, SOLIDWORKS Sustainability, SOLIDWORKS Plastics, SOLIDWORKS Electrical Schematic Standard, SOLIDWORKS Electrical Schematic Professional, SOLIDWORKS Electrical 3D, SOLIDWORKS Electrical Professional, CircuitWorks, SOLIDWORKS Composer, SOLIDWORKS Inspection, SOLIDWORKS MBD, SOLIDWORKS PCB powered by Altium, SOLIDWORKS PCB Connector powered by Altium, and SOLIDWORKS Visualize are product names of DS SolidWorks.

Other brand or product names are trademarks or registered trademarks of their respective holders.

#### COMMERCIAL COMPUTER SOFTWARE - PROPRIETARY

The Software is a "commercial item" as that term is defined at 48 C.F.R. 2.101 (OCT 1995), consisting of "commercial computer software" and "commercial software documentation" as such terms are used in 48 C.F.R. 12.212 (SEPT 1995) and is provided to the U.S. Government (a) for acquisition by or on behalf of civilian agencies, consistent with the policy set forth in 48 C.F.R. 12.212; or (b) for acquisition by or on behalf of units of the Department of Defense, consistent with the policies set forth in 48 C.F.R. 227.7202-1 (JUN 1995) and 227.7202-4 (JUN 1995).

In the event that you receive a request from any agency of the U.S. Government to provide Software with rights beyond those set forth above, you will notify DS SolidWorks of the scope of the request and DS SolidWorks will have five (5) business days to, in its sole discretion, accept or reject such request. Contractor/Manufacturer: Dassault Systemes SolidWorks Corporation, 175 Wyman Street, Waltham, Massachusetts 02451 USA.

#### Copyright Notices for SOLIDWORKS Standard, Premium, Professional, and Education Products

Portions of this software © 1986-2018 Siemens Product Lifecycle Management Software Inc. All rights reserved.

This work contains the following software owned by Siemens Industry Software Limited:

D-Cubed® 2D DCM © 2019. Siemens Industry Software Limited. All Rights Reserved.

D-Cubed® 3D DCM © 2019. Siemens Industry Software Limited. All Rights Reserved.

D-Cubed® PGM © 2019. Siemens Industry Software Limited. All Rights Reserved.

D-Cubed® CDM © 2019. Siemens Industry Software Limited. All Rights Reserved.

D-Cubed® AEM © 2019. Siemens Industry Software Limited. All Rights Reserved.

Portions of this software © 1998-2019 HCL Technologies Ltd.

Portions of this software incorporate PhysX™ by NVIDIA 2006-2010.

Portions of this software © 2001-2019 Luxology, LLC. All rights reserved, patents pending.

Portions of this software © 2007-2019 DriveWorks Ltd. © 2012, Microsoft Corporation. All rights reserved.

Includes Adobe® PDF Library technology.

Copyright 1984-2016 Adobe Systems Inc. and its licensors. All rights reserved. Protected by U.S. Patents 6,563,502; 6,639,593; 6,754,382; Patents Pending.

Adobe, the Adobe logo, Acrobat, the Adobe PDF logo, Distiller and Reader are registered trademarks or trademarks of Adobe Systems Inc. in the U.S. and other countries.

For more DS SolidWorks copyright information, see Help > About SOLIDWORKS.

#### Copyright Notices for SOLIDWORKS Simulation Products

Portions of this software © 2008 Solversoft Corporation.

PCGLSS © 1992-2017 Computational Applications and System Integration, Inc. All rights reserved.

#### Copyright Notices for SOLIDWORKS PDM Professional Product

Outside In® Viewer Technology, © 1992-2012 Oracle © 2012, Microsoft Corporation. All rights reserved.

#### Copyright Notices for eDrawings Products

Portions of this software © 2000-2014 Tech Soft 3D.

Portions of this software © 1995-1998 Jean-Loup Gailly and Mark Adler.

Portions of this software © 1998-2001 3Dconnexion.

Portions of this software © 1998-2017 Open Design Alliance. All rights reserved.

The eDrawings® for Windows® software is based in part on the work of the Independent JPEG Group.

Portions of eDrawings® for iPad® copyright © 1996-1999 Silicon Graphics Systems, Inc.

Portions of eDrawings® for iPad® copyright © 2003 – 2005 Apple Computer Inc.

#### Copyright Notices for SOLIDWORKS PCB Products

Portions of this software © 2017-2018 Altium Limited.

#### Copyright Notices for SOLIDWORKS Visualize Products

NVIDIA GameWorks™ Technology provided under license from NVIDIA Corporation. Copyright

© 2002-2015 NVIDIA Corporation. All rights reserved.

# Contents

## Introduction

About This Course .....	2
Prerequisites .....	2
Course Design Philosophy .....	2
Case Studies .....	2
Exercises .....	2
A Note About Dimensions .....	3
Conventions Used in this Book .....	3
About the Training Files .....	3
Training Templates .....	4
Accessing Training Templates in SOLIDWORKS .....	4
Windows OS .....	5
Use of Color .....	5
Color Schemes .....	5
RealView Graphics .....	5
More SOLIDWORKS Training Resources .....	6
Local User Groups .....	6

## Lesson 1

### Multibody Design Techniques

Multibody Parts .....	8
Hide/Show Tree Items .....	8
Multibody Design Techniques .....	8
Creating a Multibody .....	10
Merge Result .....	10
Case Study: Multibody Design .....	10
Contour Selection .....	11

Solid Bodies Folder .....	13
Local Operations .....	15
Feature Scope .....	15
Patterning Bodies .....	17
Tool Body Technique .....	18
Using Insert Part .....	18
External References .....	19
Entities to Transfer .....	19
Locate Part and Move/Copy Bodies .....	21
Combining Bodies .....	25
Case Study: Protective Screen .....	27
Intersect with Solid Bodies .....	31
Case Study: Bowl .....	31
Calculating Internal Volume .....	33
Indent Feature .....	34
Case Study: Indent .....	34
Deleting Solid Bodies .....	36
Delete/Keep Body Feature .....	36
Exercise 1: Bridging a Multibody Part .....	38
Exercise 2: Local Operations .....	40
Exercise 3: Positioning Inserted Parts .....	43
Exercise 4: Patterning Bodies .....	46
Exercise 5: Modeling Negative Space .....	50
Exercise 6: Combining a Multibody Part .....	53
Exercise 7: Indent .....	55
<b>Lesson 2</b>	
<b>Saving Solid Bodies</b>	
Multibody Part vs. Assembly .....	60
Saving Bodies Functions .....	61
Default Templates .....	62
Case Study: Clamp .....	62
Insert into New Part .....	63
Save Bodies .....	67
Case Study: Boat Cleat .....	67
Modeling for Rapid Tooling .....	70
Splitting a Part into Multiple Bodies .....	71
Split Feature .....	71
Case Study: Handle .....	72
Saving Split Bodies .....	73
Automating an Assembly .....	74
Case Study: Using Split Part with Legacy Data .....	75
Exercise 8: Insert into New Part .....	78
Exercise 9: Split Part and Save Bodies .....	80
Exercise 10: Modeling for Rapid Tooling .....	83

## Lesson 3

### Sketching with Splines

Curves in Sketches . . . . .	98
Using Sketch Pictures . . . . .	100
Case Study: Guitar Body . . . . .	101
Splines. . . . .	103
Standard Spline . . . . .	104
Keep it Simple . . . . .	104
Creating and Manipulating Splines. . . . .	104
Anatomy of a Spline . . . . .	107
Spline Tools . . . . .	107
Adding Spline Relations . . . . .	107
Spline Handle Basics . . . . .	107
Spline Handle Relations . . . . .	108
Changing the Shape of a Spline . . . . .	109
The Control Polygon. . . . .	109
Manipulating the Spline Handles . . . . .	109
Fully Defining Splines . . . . .	111
Evaluating Splines . . . . .	111
Spline Evaluation Tools . . . . .	112
What is Curvature? . . . . .	112
Evaluating Curve Quality using Curvature Combs . . . . .	113
Spline Parameters . . . . .	115
Other Spline Modification Tools . . . . .	116
Case Study: Two Point Spline. . . . .	118
Equal Curvature and Torsion Continuity . . . . .	118
Evaluating Continuity with Curvature Combs . . . . .	120
Analyzing Solid Geometry . . . . .	121
Display Curvature. . . . .	121
Zebra Stripes. . . . .	122
Surface Curvature Combs. . . . .	123
Case Study: Torsion Continuity . . . . .	124
Style Spline. . . . .	126
Case Study: Watering Can Handle . . . . .	126
Style Spline Types . . . . .	127
Style Spline Tools. . . . .	129
Fit Spline. . . . .	132
Case Study: Coffee Cup . . . . .	132
Fit Spline Parameters . . . . .	134
Fit Spline Tolerance . . . . .	134
Splines Summary . . . . .	136
Exercise 11: Fleur-de-lis. . . . .	137
Exercise 12: Soda Bottle. . . . .	144
Exercise 13: Spline Practice . . . . .	148
Exercise 14: Coffee Cup Handle . . . . .	150
Exercise 15: Fun with Splines . . . . .	154

**Lesson 4****Introduction to Sweeping**

Sweeping. . . . .	158
Sweep Requirements. . . . .	159
Case Study: Faux Raised Panel Door . . . . .	160
Sweep with Guide Curves. . . . .	162
Case Study: Bottle Body. . . . .	162
Pierce Relation . . . . .	164
Showing Intermediate Sections . . . . .	167
Multi-thickness Shell . . . . .	168
The SelectionManager . . . . .	169
Case Study: Hanger Bracket. . . . .	170
Exercise 16: Oval Foot Drawer Pull. . . . .	173
Symmetrical Splines . . . . .	175
Exercise 17: Tire Iron . . . . .	178
Circular Profile Sweep . . . . .	179
Dome Feature . . . . .	180
Exercise 18: Starship Fuselage . . . . .	182
Exercise 19: Build Your Own Bottle . . . . .	187

**Lesson 5****3D Sketching and Curve Features**

Curve Features . . . . .	190
Case Study: Spring . . . . .	191
Sweeping Along a 3D Path . . . . .	191
3D Sketching. . . . .	191
Using Reference Planes . . . . .	191
Additional Techniques . . . . .	191
Space Handle . . . . .	192
Subset of Sketch Entities and Relations . . . . .	192
Helix Curve. . . . .	197
Helix and Spiral Feature . . . . .	197
Creating a 3D Curve from Orthogonal Views . . . . .	200
Projected Curve Feature . . . . .	201
Combining Curves . . . . .	202
Composite Curve Feature . . . . .	202
Smoothing Transitions . . . . .	204
Exercise 20: 3D Sketching . . . . .	206
Exercise 21: 3D Sketching with Planes . . . . .	209
Activating a Plane. . . . .	213
Creating a Plane within a 3D Sketch . . . . .	215
Exercise 22: D-cell Flashlight Spring. . . . .	218
Exercise 23: Water Bottle Cage . . . . .	219

**Lesson 6****Threads and Library Feature Parts**

Bottle Features . . . . .	224
Library Feature Parts . . . . .	224
Case Study: Modeling Threads . . . . .	224
Thread Feature . . . . .	224
Thread Profile . . . . .	225
Saving a Library Feature Part . . . . .	226
Performance Considerations . . . . .	228
Performance Settings in System Options . . . . .	228
Performance Settings in Document Properties . . . . .	229
Suppressing Features . . . . .	229
Using the Freeze Bar . . . . .	230
Case Study: Adding the Label Outline . . . . .	232
Designing a Library Feature Part . . . . .	232
Library Feature File Locations . . . . .	233
Anatomy of a Library Feature Part . . . . .	234
File Explorer . . . . .	235
Dissolve Library Feature . . . . .	237
Creating the Sweep Path . . . . .	238
Splitting a Face . . . . .	238
Sweeping Along Model Edges . . . . .	240
Propagate Along Tangent Edges . . . . .	240
Exercise 24: Worm Gear . . . . .	243
Exercise 25: Adding the Bottle Lip . . . . .	248
Exercise 26: Starship Continued . . . . .	254

**Lesson 7****Advanced Sweeping**

Sweep Options . . . . .	266
Additional Sweep Settings . . . . .	267
Profile Orientation . . . . .	268
Intermediate Sections . . . . .	268
Follow Path . . . . .	269
Keep Normal Constant . . . . .	269
Case Study: Keep Normal Constant . . . . .	271
Intersection Curve Feature . . . . .	271
Visualizing Sweep Sections . . . . .	272
Face Curves . . . . .	272
Controlling Twist . . . . .	274
Case Study: Controlling Twist . . . . .	275
Case Study: Controlling Twist with Guide Curves . . . . .	279
Case Study: Align with End Faces . . . . .	287
Sweeping Along Non-tangent Edges . . . . .	288

Solid Profile .....	290
Case Study: Drill Bit .....	290
Exercise 27: Twist Along Path .....	293
Defining Twist .....	293
Exercise 28: Controlling Twist with Guide Curves .....	295
Equation Driven Curve .....	295
What do the Equations Mean? .....	296
Exercise 29: Makeup Case .....	299
Exercise 30: Mouse .....	302
Exercise 31: Blower Housing .....	306

## Lesson 8

### Introduction to Loft and Boundary Features

Comparing Complex Features .....	320
How Lofting and Boundary Work .....	322
Case Study: Defroster Vent .....	323
Loft Feature .....	323
Preparation of the Profiles .....	324
Merge Tangent Faces .....	326
Start and End Constraints .....	327
Boundary Feature .....	329
Boundary with Surfaces .....	332
SelectionManager in Loft and Boundary .....	333
Case Study: Lofted Merge .....	333
Case Study: Reusing Sketches .....	335
Copying a Sketch .....	336
Modify Sketch .....	337
Derived Sketches .....	339
Boundary Preview Options .....	341
Sketch Block and Library Feature Profiles .....	343
Exercise 32: Lofted Vase .....	344
Exercise 33: Creating a Transition .....	347
Exercise 34: Light Cover .....	351
Exercise 35: Sketch Blocks as Profiles .....	354
Curve Through XYZ .....	354
Sketch Blocks .....	357



**Lesson 9****Advanced Loft and Boundary Features**

Additional Curves in Loft and Boundary . . . . .	362
Centerline Lofting . . . . .	362
Case Study: Heat Shield . . . . .	362
Sharing Sketches . . . . .	364
Loft Preview Options . . . . .	365
Adding Sketch Segments . . . . .	367
Segment . . . . .	367
Split Entities . . . . .	367
Cleaning Up a Model . . . . .	369
Deleting Faces . . . . .	370
Delete Face Feature . . . . .	370
Evaluating Edges . . . . .	371
Deviation Analysis . . . . .	371
Face Fillets . . . . .	372
Case Study: Hook . . . . .	376
Planning a Modeling Strategy . . . . .	377
Curve Influence . . . . .	382
Exercise 36: Hook Continued . . . . .	385
Exercise 37: Funnel . . . . .	390
Conics . . . . .	390
Exercise 38: Rocker Arm . . . . .	400

**Lesson 10****Advanced Filleting and Other Features**

Fillet Settings . . . . .	406
Fillet Parameters . . . . .	407
Fillet Method . . . . .	407
Fillet Profile . . . . .	408
Constant Size Fillets . . . . .	409
Multiple Radius . . . . .	409
Setback Parameters . . . . .	410
Delete Face: Delete and Fill . . . . .	412
Partial Edge Parameters . . . . .	413
Fillet Options . . . . .	413
Select Through Faces . . . . .	413
Keep Features . . . . .	414
Round Corners . . . . .	416
Overflow Options . . . . .	416

Variable Size Fillets . . . . .	418
Variable Size Control Points. . . . .	419
Variable Size Fillet Profile . . . . .	420
Straight and Smooth Transitions. . . . .	421
Zero Radius Values. . . . .	421
Face Fillets . . . . .	422
Curvature Continuous Fillets . . . . .	424
Radial or Chord Width Definition . . . . .	425
Hold Lines. . . . .	425
FilletXpert. . . . .	427
Other Advanced Features . . . . .	432
Wrap Feature. . . . .	432
Deform Feature. . . . .	434
Point Deformation. . . . .	435
Curve to Curve Deformation . . . . .	437
Surface Push Deformation . . . . .	439
Joining Surfaces . . . . .	439
Knit Surface Feature . . . . .	439
Direct Editing . . . . .	443
Move Face Feature . . . . .	443
Exercise 39: Variable Radius Fillet . . . . .	447
Exercise 40: Face Fillets. . . . .	449
Exercise 41: Bottle Fillets. . . . .	450
Exercise 42: Watering Can . . . . .	453
Exercise 43: Delete Face. . . . .	459
Exercise 44: Direct Editing. . . . .	461