SOLIDWORKS®

SOLIDWORKS Simulation Premium: Dynamics

Dassault Systèmes SolidWorks Corporation
175 Wyman Street
Waltham, Massachusetts 02451 USA
In the event that you receive a request from any agency of the Department of Defense, consistent with the policies set forth in 12.212; or (b) for acquisition by or on behalf of units of the software as such commercial computer software documentation as such commercial item as defined at 48 C.F.R. 2.101 (OCT 1995), consisting of commercial computer software and commercial software documentation 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; 6,988,560; 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.


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 Lifecycle Management Software Inc. All rights reserved.

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


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.


**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.

**Document Number:** PMT2045-ENG
Contents

Introduction

About This Course .................................................. 2
Prerequisites .......................................................... 2
Course Design Philosophy ......................................... 2
Course Length ........................................................ 2
Using this Book ...................................................... 2
Laboratory Exercises ............................................... 2
About the Training Files ............................................ 3
Windows .................................................................. 3
User Interface Appearance ....................................... 3
Conventions Used in this Book ................................. 3
Use of Color ............................................................ 4
More SOLIDWORKS Training Resources. ................. 4
   Local User Groups ................................................ 4
What is SOLIDWORKS Simulation? .......................... 5
## Lesson 1: Vibration of a Pipe

Objectives .................................................. 7
Problem Description .................................. 8
Static Analysis .......................................... 8
Frequency Analysis ................................. 11
  Discussion ............................................. 12
Dynamic Analysis (Slow Force) ................. 13
  Linear Dynamic Analysis ........................ 13
  Discussion ........................................... 19
Dynamic Analysis (Fast Force) ................. 20
Summary .................................................. 22
Questions ................................................ 22
Exercise 1: Vibration of Cantilever Beam .... 23
Exercise 2: Shock Load of PCB Board ......... 29
  Summary .............................................. 34

## Lesson 2: Transient Shock Analysis According to MILS-STD-810H

Objectives .................................................. 35
Problem Description ............................... 36
  Mass Participation Factor ....................... 41
  Cumulative Mass Participation Factor ......... 43
  Damping .............................................. 44
  Viscous Damping .................................. 45
  Time Step ............................................ 49
Model with Remote Mass ......................... 58
  Remote Mass ....................................... 58
Summary .................................................. 63
Questions ................................................ 63
Exercise 3: Transient Analysis of Alternator Bracket 64
  Maximum Number of Time Increments ....... 70
  Summary .............................................. 73

## Lesson 3: Harmonic Analysis of a Bracket

Objectives .................................................. 75
Project Description ................................. 76
  Harmonic Analysis Basics ....................... 76
  Single DOF Oscillator ............................ 77
Harmonic Analysis of a Bracket .............. 78
  Harmonic Study Properties .................... 81
Summary .................................................. 86
Questions ................................................ 86
Exercise 4: Harmonic Analysis of Alternator Bracket 87
Lesson 4:
Response Spectrum Analysis

Objectives ................................................................. 93
Response Spectrum Analysis ........................................ 94
Response Spectrum ...................................................... 94
  Response Spectrum Analysis Procedure ....................... 95
Project Description .................................................... 95
  Response Spectrum Input .......................................... 99
  Mode Combination Method .................................... 101
Summary ................................................................. 103
Questions .............................................................. 103

Lesson 5:
Random Vibration Analysis According to MIL-STD-810G

Objectives ................................................................. 105
Project Description .................................................... 106
  Distributed Mass .................................................. 111
  Random Vibration Analysis ..................................... 115
  Power Spectral Density Function ............................. 118
  Overall Level of Acceleration PSD ......................... 120
  Decibels .......................................................... 121
  Random Study Properties .................................... 123
  Advanced Options .............................................. 124
  RMS Results ..................................................... 124
  PSD Results ...................................................... 127
  1s, 2s, 3s, ... Results ........................................ 128
Summary ................................................................. 130
References ............................................................. 130
Questions .............................................................. 131
Exercise 5: Random Vibration Analysis of
an Electronics Enclosure ........................................... 132
Exercise 6: Circuit Board Fatigue Estimates ..................... 141
Exercise 7: Random Vibration Analysis of a Starter Motor .... 146

Lesson 6:
Random Vibration Fatigue

Objectives ................................................................. 153
Project Description .................................................... 154
  Random Vibration Fatigue ....................................... 155
  Material Properties, S-N Curve ............................ 155
  Random Vibration Fatigue Options ......................... 158
Summary ................................................................. 160
Exercise 8: Random Vibration Fatigue of a Cantilever Beam . 163
Lesson 7: Nonlinear Dynamic Analysis of an Electronic Enclosure

Objectives ....................................................... 169
Project Description ........................................... 170
Linear Dynamic Analysis ................................. 170
Nonlinear Dynamic Analysis ......................... 172
  Linear vs. Nonlinear Dynamic Analysis .......... 172
  Rayleigh Damping ....................................... 174
  Time Integration Methods ............................. 175
  Iterative Methods ...................................... 176
  Discussion .............................................. 178
Summary ...................................................... 179
Questions .................................................... 179