



DEITEL® DEVELOPER SERIES

The New Language for
iOS® and OS X® Developers

Swift™

for Programmers

PAUL DEITEL • HARVEY DEITEL

FREE SAMPLE CHAPTER



SHARE WITH OTHERS

SWIFT™ FOR PROGRAMMERS
DEITEL® DEVELOPER SERIES



Many of the designations used by manufacturers and sellers to distinguish their products are claimed as trademarks. Where those designations appear in this book, and the publisher was aware of a trademark claim, the designations have been printed with initial capital letters or in all capitals.

The authors and publisher have taken care in the preparation of this book, but make no expressed or implied warranty of any kind and assume no responsibility for errors or omissions. No liability is assumed for incidental or consequential damages in connection with or arising out of the use of the information or programs contained herein.

For information about buying this title in bulk quantities, or for special sales opportunities (which may include electronic versions; custom cover designs; and content particular to your business, training goals, marketing focus, or branding interests), please contact our corporate sales department at corpsales@pearsoned.com or (800) 382-3419.

For government sales inquiries, please contact governmentsales@pearsoned.com.

For questions about sales outside the U.S., please contact international@pearsoned.com.

Visit us on the web: informit.com/ph

Library of Congress Cataloging-in-Publication Data

On file

© 2015 Pearson Education, Inc.

All rights reserved. Printed in the United States of America. This publication is protected by copyright, and permission must be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. To obtain permission to use material from this work, please submit a written request to Pearson Education, Inc., Permissions Department, One Lake Street, Upper Saddle River, New Jersey 07458, or you may fax your request to (201) 236-3290.

ISBN-13: 978-0-13402136-2

ISBN-10: 0-13-402136-3

Text printed in the United States at Edwards Brothers Malloy in Ann Arbor, Michigan.

First printing, January 2015

SWIFT™ FOR PROGRAMMERS

DEITEL® DEVELOPER SERIES

Paul Deitel • Harvey Deitel
Deitel & Associates, Inc.



Upper Saddle River, NJ • Boston • Indianapolis • San Francisco
New York • Toronto • Montreal • London • Munich • Paris • Madrid
Capetown • Sydney • Tokyo • Singapore • Mexico City

Deitel® Series Page

Deitel® Developer Series

Android for Programmers: An App-Driven Approach, 2/E, Volume 1
C for Programmers with an Introduction to C11
C++11 for Programmers
C# 2012 for Programmers
iOS® 8 for Programmers: An App-Driven Approach with Swift™, Volume 1
Java™ for Programmers, 3/E
JavaScript for Programmers
Swift™ for Programmers

How To Program Series

Android How to Program, 2/E
C++ How to Program, 9/E
C How to Program, 7/E
Java™ How to Program, Early Objects Version, 10/E
Java™ How to Program, Late Objects Version, 10/E
Internet & World Wide Web How to Program, 5/E
Visual Basic® 2012 How to Program, 6/E
Visual C#® 2012 How to Program, 5/E

Simply Series

Simply C++: An App-Driven Tutorial Approach
Simply Java™ Programming: An App-Driven Tutorial Approach
(continued in next column)

(continued from previous column)

Simply C#: An App-Driven Tutorial Approach
Simply Visual Basic® 2010: An App-Driven Approach, 4/E

CourseSmart Web Books

www.deitel.com/books/CourseSmart/
C++ How to Program, 8/E and 9/E
Simply C++: An App-Driven Tutorial Approach
Java™ How to Program, 9/E and 10/E
Simply Visual Basic® 2010: An App-Driven Approach, 4/E
Visual Basic® 2012 How to Program, 6/E
Visual Basic® 2010 How to Program, 5/E
Visual C#® 2012 How to Program, 5/E
Visual C#® 2010 How to Program, 4/E

LiveLessons Video Learning Products

www.deitel.com/books/LiveLessons/
Android App Development Fundamentals, 2/e
C++ Fundamentals
Java™ Fundamentals, 2/e
C# 2012 Fundamentals
C# 2010 Fundamentals
iOS® 8 App Development Fundamentals, 3/e
JavaScript Fundamentals
Swift™ Fundamentals

To receive updates on Deitel publications, Resource Centers, training courses, partner offers and more, please join the Deitel communities on

- Facebook®—[facebook.com/DeitelFan](https://www.facebook.com/DeitelFan)
- Twitter®—[@deitel](https://twitter.com/deitel)
- Google+™—[google.com/+DeitelFan](https://plus.google.com/+DeitelFan)
- YouTube™—[youtube.com/DeitelTV](https://www.youtube.com/DeitelTV)
- LinkedIn®—[linkedin.com/company/deitel-&-associates](https://www.linkedin.com/company/deitel-&-associates)

and register for the free *Deitel® Buzz Online* e-mail newsletter at:

www.deitel.com/newsletter/subscribe.html

To communicate with the authors, send e-mail to:

deitel@deitel.com

For information on *Dive-Into® Series* on-site seminars offered by Deitel & Associates, Inc. worldwide, write to us at deitel@deitel.com or visit:

www.deitel.com/training/

For continuing updates on Pearson/Deitel publications visit:

www.deitel.com
www.pearsonhighered.com/deitel/

Visit the Deitel Resource Centers that will help you master programming languages, software development, Android and iOS app development, and Internet- and web-related topics:

www.deitel.com/ResourceCenters.html

In Loving Memory of Aunt Rochelle Deitel:

*The most positive person we ever knew.
You brought joy to our lives.*

Harvey, Barbara, Paul and Abbey

Trademarks

DEITEL, the double-thumbs-up bug and DIVE-INTO are registered trademarks of Deitel & Associates, Inc.

Apple, iOS, iPhone, iPad, iPod touch, Xcode, Swift, Objective-C, Cocoa and Cocoa Touch are trademarks or registered trademarks of Apple, Inc.

Java is a registered trademark of Oracle and/or its affiliates. Other names may be trademarks of their respective owners.

Throughout this book, trademarks are used. Rather than put a trademark symbol in every occurrence of a trademarked name, we state that we are using the names in an editorial fashion only and to the benefit of the trademark owner, with no intention of infringement of the trademark.



Contents

Preface

xix

Before You Begin

xxvii

1	Introduction to Swift and Xcode 6	1
1.1	Introduction	2
1.2	Apple's OS X [®] and iOS [®] Operating Systems: A Brief History	3
1.3	Objective-C	3
1.4	Swift: Apple's Programming Language of the Future	4
1.4.1	Key Features of Many Popular Languages	4
1.4.2	Performance	6
1.4.3	Error Prevention	6
1.4.4	Swift Standard Library	6
1.4.5	Swift Apps and the Cocoa [®] and Cocoa Touch [®] Frameworks	7
1.4.6	Swift and Objective-C Interoperability	9
1.4.7	Other Apple Swift Resources	9
1.5	Can I Use Swift Exclusively?	9
1.5.1	Objective-C Programmers Who Are Developing New iOS and OS X Apps	10
1.5.2	Objective-C Programmers Who Are Enhancing Existing iOS and OS X Apps	10
1.5.3	Java, C++ and C# Programmers Who Are New to iOS and OS X App Development	10
1.5.4	Significant Language Changes Expected	10
1.5.5	A Mixture of Swift and Objective-C	10
1.6	Xcode 6 Integrated Development Environment	10
1.7	Creating Swift Apps with Xcode 6	13
1.8	Web Resources	18
2	Introduction to Swift Programming	20
2.1	Introduction	21
2.2	A First Swift Program: Printing a Line of Text	21
2.3	Modifying Your First Program	23
2.4	Composing Larger Strings with String Interpolation	25
2.5	Another Application: Adding Integers	27

2.6	Arithmetic	28
2.6.1	Automatic Arithmetic Overflow Checking	29
2.6.2	Operator Precedence	29
2.7	Decision Making: The <code>if</code> Conditional Statement and the Comparative Operators	29
2.8	Wrap-Up	32

3 Introduction to Classes, Objects, Methods and Functions 33

3.1	Introduction	34
3.2	Account Class	35
3.2.1	Defining a Class	35
3.2.2	Defining a Class Attribute as a Stored Property	36
3.2.3	Defining a <code>public</code> Stored Property with a <code>private</code> Setter	37
3.2.4	Initializing a Class's Properties with <code>init</code>	37
3.2.5	Defining a Class's Behaviors as Methods	39
3.3	Creating and Using Account Objects	40
3.3.1	Importing the Foundation Framework	40
3.3.2	Creating and Configuring an <code>NSNumberFormatter</code> to Format Currency Values	41
3.3.3	Defining a Function— <code>formatAccountString</code>	42
3.3.4	Creating Objects and Calling an Initializer	42
3.3.5	Calling Methods on Objects—Depositing into Account Objects	43
3.3.6	Calling Methods on Objects—Withdrawing from Account Objects	44
3.4	Value Types vs. Reference Types	45
3.5	Software Engineering with Access Modifiers	46
3.6	Wrap-Up	47

4 Control Statements; Assignment, Increment and Logical Operators 48

4.1	Introduction	49
4.2	Control Statements	49
4.3	<code>if</code> Conditional Statement	50
4.4	<code>if...else</code> Conditional Statement	50
4.5	Compound Assignment Operators	52
4.6	Increment and Decrement Operators	53
4.7	<code>switch</code> Conditional Statement	55
4.7.1	Using a <code>switch</code> Statement to Convert Numeric Grades to Letter Grades	55
4.7.2	Specifying Grade Ranges with the Closed-Range Operator (<code>...</code>)	56
4.7.3	The <code>default</code> Case	56
4.7.4	Other Patterns in the <code>case</code> Label	57
4.7.5	No Automatic Fall Through as in Other C-Based Languages	57

4.8	<code>while</code> Loop Statement	57
4.9	<code>do...while</code> Loop Statement	58
4.10	<code>for...in</code> Loop Statement and the Range Operators	58
4.10.1	Iterating Over Collections of Values with Closed Ranges, Half-Open Ranges and the Global <code>stride</code> Function	59
4.10.2	Compound-Interest Calculations with <code>for...in</code>	60
4.10.3	Formatting Strings with Field Widths and Justification	61
4.10.4	Performing the Interest Calculations	62
4.10.5	A Warning about Displaying Rounded Values	62
4.11	<code>for</code> Loop Statement	63
4.11.1	General Format of a <code>for</code> Statement	64
4.11.2	Scope of a <code>for</code> Statement's Control Variable	64
4.11.3	Expressions in a <code>for</code> Statement's Header Are Optional	64
4.12	<code>break</code> and <code>continue</code> Statements	64
4.12.1	<code>break</code> Statement Example	64
4.12.2	<code>continue</code> Statement Example	65
4.13	Logical Operators	66
4.13.1	Logical AND (<code>&&</code>) Operator	66
4.13.2	Logical OR (<code> </code>) Operator	67
4.13.3	Short-Circuit Evaluation of Complex Conditions	67
4.13.4	Logical NOT (<code>!</code>) Operator	68
4.14	Wrap-Up	69

5 Functions and Methods: A Deeper Look; enums and Tuples 70

5.1	Introduction	71
5.2	Modules in Swift	72
5.3	Darwin Module—Using Predefined C Functions	73
5.4	Multiple-Parameter Function Definition	74
5.5	Random-Number Generation	76
5.6	Introducing Enumerations and Tuples	77
5.6.1	Introducing Enumeration (<code>enum</code>) Types	80
5.6.2	Tuples and Multiple Function Return Values	82
5.6.3	Tuples as Function Arguments	83
5.6.4	Accessing the Raw Value of an <code>enum</code> Constant	83
5.7	Scope of Declarations	84
5.8	Function and Method Overloading	86
5.9	External Parameter Names	88
5.10	Default Parameter Values	89
5.11	Passing Arguments by Value or by Reference	90
5.12	Recursion	92
5.13	Nested Functions	93
5.14	Wrap-Up	95

6	Arrays and an Introduction to Closures	96
6.1	Introduction	97
6.2	Arrays	98
6.3	Creating and Initializing Arrays	99
6.4	Iterating through Arrays	101
6.5	Adding and Removing Array Elements	104
6.6	Subscript Expressions with Ranges	107
6.7	Sorting Arrays; Introduction to Closures	108
6.7.1	Closures and Closure Expressions	108
6.7.2	Array Methods <code>sort</code> and <code>sorted</code>	109
6.7.3	Sorting with Function <code>ascendingOrder</code>	111
6.7.4	Using a Fully Typed Closure Expression	111
6.7.5	Using a Closure Expression with Inferred Types	111
6.7.6	Using a Closure Expression with Inferred Types and an Implicit <code>return</code>	112
6.7.7	Using a Closure Expression with Shorthand Argument Names	112
6.7.8	Using an Operator Function as a Closure Expression	112
6.7.9	Reversing an Array's Elements	112
6.8	Array Methods <code>filter</code> , <code>map</code> and <code>reduce</code>	112
6.8.1	Filtering an Array	114
6.8.2	Mapping an Array's Elements to New Values	115
6.8.3	Reducing an Array's Elements to a Single Value	115
6.8.4	Combining Filtering, Mapping and Reducing	116
6.9	Card Shuffling and Dealing Simulation; Computed Properties; Optionals	116
6.9.1	Class <code>Card</code>	116
6.9.2	Class <code>DeckOfCards</code>	117
6.9.3	<code>DeckOfCards</code> Initializer	118
6.9.4	<code>DeckOfCards</code> Method <code>shuffle</code>	119
6.9.5	<code>DeckOfCards</code> Method <code>dealCard</code> and Optional Return Values	119
6.9.6	Shuffling and Dealing Cards	119
6.9.7	Unwrapping Optional Values with Optional Binding and the <code>if</code> or <code>while</code> Statements	121
6.10	Passing Arrays to Functions	121
6.10.1	Passing an Entire Array By Value	123
6.10.2	Passing One Array Element By Value	123
6.10.3	Passing an Entire Array By Reference	123
6.10.4	Passing One Array Element By Reference	124
6.11	Notes on Pass-By-Value and Pass-By-Reference	124
6.12	Multidimensional Arrays	124
6.13	Variadic Parameters	128
6.14	Wrap-Up	129

7	Dictionary	131
7.1	Introduction	132

7.1.1	What Is a Dictionary?	132
7.1.2	Dictionary Examples	133
7.1.3	Dictionary is a Generic Type	133
7.1.4	Dictionary Is a Value Type	133
7.1.5	Dictionary Is Implemented as a Hash Table	134
7.1.6	Dictionary Is Type Safe	134
7.2	Declaring a Dictionary: Key–Value Pairs and Dictionary Literals	134
7.2.1	Dictionary Key–Value Pairs and Dictionary Literals	135
7.2.2	Declaring a Dictionary with Generics and Explicit Typing	136
7.2.3	Declaring a Dictionary with Type Inference	136
7.2.4	Invoking Dictionary’s description Property Explicitly and Implicitly	136
7.3	Declaring and Printing Empty Dictionary Objects	136
7.4	Iterating through a Dictionary with for...in	137
7.5	General-Purpose Generic Dictionary Printing Function	139
7.6	Dictionary Equality Operators == and !=	140
7.7	Dictionary count and isEmpty Properties	141
7.8	Dictionary Whose Values Are Arrays	142
7.9	Dictionary’s keys and values Properties	143
7.10	Inserting, Modifying and Removing Key–Value Pairs with Subscripting	145
7.10.1	Updating the Value of an Existing Key–Value Pair	147
7.10.2	Adding a New Key–Value Pair	147
7.10.3	Removing a Key–Value Pair	147
7.10.4	Subscripting Returns an Optional Value	147
7.10.5	Processing an Optional Value	148
7.10.6	Inserting a New Key–Value Pair in an Empty Dictionary	148
7.11	Inserting, Removing and Modifying Key–Value Pairs	148
7.11.1	Inserting a Key–Value Pair with Dictionary Method updateValue	150
7.11.2	Updating a Key–Value Pair with Dictionary Method updateValue	151
7.11.3	Removing a Key–Value Pair with Dictionary Method removeValueForKey	151
7.11.4	Attempting to Remove a Nonexistent Key–Value Pair with Method removeValueForKey	151
7.11.5	Emptying a Dictionary with Method removeAll	151
7.12	Building a Dictionary Dynamically: Word Counts in a String	151
7.13	Bridging Between Dictionary and Foundation Classes	153
7.14	Hash Tables and Hashing	154
7.15	Wrap-Up	155

8 **Classes: A Deeper Look and Extensions** **157**

8.1	Introduction	158
8.2	Time Class: Default Initializers and Property Observers	160
8.2.1	Stored Property Initialization and the Default_INITIALIZER	162

8.2.2	<code>willSet</code> and <code>didSet</code> Property Observers for Stored Properties	162
8.2.3	Computed Read-Only Properties <code>universalDescription</code> and <code>description</code>	163
8.2.4	Using <code>Class Time</code>	164
8.3	Designated and Convenience Initializers in <code>Class Time</code>	166
8.3.1	<code>Class Time</code> with Overloaded Initializers	166
8.3.2	Designated Initializers	167
8.3.3	Convenience Initializers and Initializer Delegation with <code>self</code>	168
8.3.4	Using <code>Class Time</code> 's Designated and Convenience Initializers	169
8.4	Failable Initializers in <code>Class Time</code>	170
8.4.1	Failable Designated Initializers	172
8.4.2	Failable Convenience Initializers	172
8.4.3	Implicitly Unwrapped Failable Initializers	173
8.4.4	Invoking Failable Initializers	173
8.5	Extensions to <code>Class Time</code>	174
8.5.1	<code>Class Time</code> with Extensions	175
8.5.2	Testing <code>Class Time</code> 's Extensions	177
8.5.3	Extensions and Access Modifiers	178
8.6	Read-Write Computed Properties	178
8.7	Composition	181
8.7.1	<code>Class Employee</code>	181
8.7.2	Testing <code>Class Employee</code>	183
8.8	Automatic Reference Counting, Strong References and Weak References	184
8.9	Deinitializers	185
8.10	Using <code>NSDecimalNumber</code> for Precise Monetary Calculations	185
8.11	Type Properties and Type Methods	187
8.11.1	Type Scope	188
8.11.2	Motivating Type Properties	188
8.11.3	Creating Type Properties and Type Methods in Classes	189
8.11.4	Using Type Properties and Type Methods	190
8.12	Lazy Stored Properties and Delayed Initialization	191
8.13	Wrap-Up	192

9 Structures, Enumerations and Nested Types **194**

9.1	Introduction	195
9.2	Structure Definitions	196
9.2.1	<code>Time struct</code> Definition with Default and Memberwise Initializers	198
9.2.2	Custom Initializers extension to <code>struct Time</code>	198
9.2.3	Computed Properties extension to <code>struct Time</code>	199
9.2.4	Mutating Methods extension to <code>struct Time</code>	199
9.2.5	Testing the <code>Time struct</code>	200
9.3	Enumerations and Nested Types	202
9.3.1	<code>Card struct</code> with Nested <code>Suit</code> and <code>Face enum</code> Types	202
9.3.2	<code>DeckOfCards struct</code>	205

9.3.3	Testing the struct Types Card and DeckOfCards, and the enum Types Suit and Face	207
9.4	Choosing Among Structures, Enumerations and Classes in Your Apps	209
9.5	Associated Values for enums	210
9.6	Wrap-Up	212

10 Inheritance, Polymorphism and Protocols 214

10.1	Introduction	215
10.1.1	Superclasses and Subclasses	215
10.1.2	Polymorphism	216
10.1.3	Implementing for Extensibility	216
10.1.4	Programming in the Specific	216
10.1.5	Protocols	217
10.2	Superclasses and Subclasses	217
10.3	An Inheritance Hierarchy: CommunityMembers	218
10.4	Case Study: Using Inheritance to Create Related Employee Types	218
10.4.1	Superclass CommissionEmployee	220
10.4.2	Subclass BasePlusCommissionEmployee	221
10.4.3	Testing the Class Hierarchy	224
10.5	Access Modifiers in Inheritance Hierarchies	226
10.6	Introduction to Polymorphism: A Polymorphic Video Game Discussion	227
10.7	Case Study: Payroll System Class Hierarchy Using Polymorphism	228
10.7.1	Base Class Employee	229
10.7.2	Subclass SalariedEmployee	231
10.7.3	Subclass CommissionEmployee	232
10.7.4	Indirect Subclass BasePlusCommissionEmployee	233
10.7.5	Polymorphic Processing	235
10.8	Case Study: Creating and Using Custom Protocols	238
10.8.1	Protocol Capabilities Must Be Defined in Each Conforming Type	238
10.8.2	Protocols and <i>Is-a</i> Relationships	238
10.8.3	Relating Disparate Types Via Protocols	238
10.8.4	Accounts-Payable Application	239
10.8.5	Developing a Payable Hierarchy	239
10.8.6	Declaring Protocol Payable	240
10.8.7	Creating Class Invoice	241
10.8.8	Using extensions to Add Printable and Payable Protocol Conformance to Class Employee	242
10.8.9	Using Protocol Payable to Process Invoices and Employees Polymorphically	244
10.9	Additional Protocol Features	246
10.9.1	Protocol Inheritance	246
10.9.2	Class-Only Protocols	246
10.9.3	Optional Capabilities in Protocols	246
10.9.4	Protocol Composition	247
10.9.5	Common Protocols in Swift	247

10.10	Using <code>final</code> to Prevent Method Overriding and Inheritance	248
10.11	Initialization and Deinitialization in Class Hierarchies	248
10.11.1	Basic Class-Instance Initialization	248
10.11.2	Initialization in Class Hierarchies	249
10.11.3	Initialization of a <code>BasePlusCommissionEmployee</code> Object	250
10.11.4	Overriding Initializers and Required Initializers	250
10.11.5	Deinitialization in Class Hierarchies	251
10.12	Wrap-Up	251

11 Generics **253**

11.1	Introduction	254
11.2	Motivation for Generic Functions	254
11.3	Generic Functions: Implementation and Specialization	255
11.4	Type Parameters with Type Constraints	258
11.5	Overloading Generic Functions	259
11.6	Generic Types	259
11.7	Note About Associated Types for Protocols	263
11.8	Wrap-Up	263

12 Operator Overloading and Subscripts **264**

12.1	Introduction	265
12.2	String Operators and Methods	266
12.2.1	String Variables and Constants	268
12.2.2	String Comparative Operators	268
12.2.3	Custom String Unary Prefix Operator <code>!</code>	269
12.2.4	String Concatenation with Operators <code>+</code> and <code>+=</code>	269
12.2.5	String Subscript (<code>[]</code>) Operator for Creating Substrings	270
12.2.6	Other String Methods	270
12.3	Custom Complex Numeric Type with Overloaded Arithmetic Operators	271
12.3.1	Overloaded Operator Functions <code>+</code> , <code>-</code> and <code>*</code>	272
12.3.2	Overloading the Arithmetic Assignment Operator <code>+=</code>	272
12.3.3	Performing Arithmetic with Complex Numbers	273
12.4	Overloading Arithmetic Operators for Class <code>NSDecimalNumber</code>	274
12.4.1	Overloading the Multiplication Operator (<code>*</code>)	275
12.4.2	Overloading the Addition Operator (<code>+</code>)	276
12.4.3	Using the Overloaded Operators	276
12.4.4	Overloading the <code>*=</code> Multiplication Assignment Operator	276
12.5	Overloading Unary Operators: <code>++</code> and <code>--</code>	276
12.5.1	Overloading Unary Prefix Operators That Modify Their Operands	278
12.5.2	Overloading Unary Postfix Operators That Modify Their Operands	278
12.5.3	Swift's <code>AnyObject</code> Type—Bridging Between Objective-C and Swift	278
12.6	Overloading Subscripts	279

12.6.1	Box Type with Custom Subscripts	279
12.6.2	Subscript Syntax	281
12.6.3	Type Box's Int Subscript and the precondition Function	281
12.6.4	Type Box's String Subscript	282
12.6.5	Using Type Box's Subscripts	282
12.7	Custom Operators	283
12.7.1	Precedence and Associativity	283
12.7.2	Symbols Used in Custom Operators	284
12.7.3	Defining a Custom Exponentiation Operator for Type Int	285
12.8	Custom Generic Operators	286
12.9	Wrap-Up	287

13 iOS 8 App Development: Welcome App **288**

13.1	Introduction	289
13.2	Technologies Overview	290
13.2.1	Xcode and Interface Builder	290
13.2.2	Labels and Image Views	290
13.2.3	Asset Catalogs and Image Sets	291
13.2.4	Running the App	291
13.2.5	Accessibility	291
13.2.6	Internationalization	291
13.3	Creating a Universal App Project with Xcode	291
13.3.1	Xcode Projects and App Templates	291
13.3.2	Creating and Configuring a Project	292
13.4	Xcode Workspace Window	293
13.4.1	Navigator Area	294
13.4.2	Editor Area	294
13.4.3	Utilities Area and Inspectors	295
13.4.4	Debug Area	295
13.4.5	Xcode Toolbar	295
13.4.6	Project Navigator	296
13.4.7	Keyboard Shortcuts	296
13.5	Storyboarding the Welcome App's UI	296
13.5.1	Configuring the App for Portrait and Landscape Orientations	297
13.5.2	Providing an App Icon	297
13.5.3	Creating an Image Set for the App's Image	299
13.5.4	Overview of the Storyboard and the Xcode Utilities Area	300
13.5.5	Adding an Image View to the UI	302
13.5.6	Using Inspectors to Configure the Image View	302
13.5.7	Adding and Configuring the Label	304
13.5.8	Using Auto Layout to Support Different Screen Sizes and Orientations	306
13.6	Running the Welcome App	308
13.6.1	Testing on the iOS Simulator	308

13.6.2	Testing on a Device (for Paid Apple iOS Developer Program Members Only)	311
13.7	Making Your App Accessible	311
13.7.1	Enabling Accessibility for the Image View	311
13.7.2	Confirming Accessibility Text with the Simulator's Accessibility Inspector	312
13.8	Internationalizing Your App	313
13.8.1	Locking Your UI During Translation	314
13.8.2	Exporting Your UI's String Resources	315
13.8.3	Translating the String Resources	316
13.8.4	Importing the Translated String Resources	316
13.8.5	Testing the App in Spanish	317
13.9	Wrap-Up	318

14 **iOS 8 App Development: Tip Calculator App** **319**

14.1	Introduction	320
14.2	Test-Driving the Tip Calculator App in the iPhone and iPad Simulators	321
14.3	Technologies Overview	322
14.3.1	Swift Programming	322
14.3.2	Swift Apps and the Cocoa Touch® Frameworks	322
14.3.3	Using the UIKit and Foundation Frameworks in Swift Code	323
14.3.4	Creating Labels , a Text Field and a Slider with Interface Builder	324
14.3.5	View Controllers	324
14.3.6	Linking UI Components to Your Swift Code	324
14.3.7	Performing Tasks After a View Loads	325
14.3.8	Bridging Between Swift and Objective-C Types	325
14.4	Building the App's UI	325
14.4.1	Creating the Project	325
14.4.2	Configuring the Size Classes for Designing a Portrait Orientation iPhone App	327
14.4.3	Adding the UI Components	327
14.4.4	Adding the Auto Layout Constraints	334
14.5	Creating Outlets with Interface Builder	337
14.6	Creating Actions with Interface Builder	340
14.7	Class <code>ViewController</code>	341
14.7.1	<code>import</code> Declarations	342
14.7.2	<code>ViewController</code> Class Definition	342
14.7.3	<code>ViewController</code> 's <code>@IBOutlet</code> Properties	342
14.7.4	Other <code>ViewController</code> Properties	343
14.7.5	Overridden <code>UIViewController</code> method <code>viewDidLoad</code>	344
14.7.6	<code>ViewController</code> Action Method <code>calculateTip</code>	345
14.7.7	Global Utility Functions Defined in <code>ViewController.swift</code>	347
14.8	Wrap-Up	349

A	Keywords	351
B	Operator Precedence Chart	352
C	Labeled break and continue Statements	354
C.1	Introduction	354
C.2	Labeled break Statement	354
C.3	Labeled continue Statement	355
	Index	357

This page intentionally left blank



Preface

Welcome to Apple’s new Swift programming language and *Swift for Programmers*! This book presents leading-edge computing technologies for software developers. It’s designed primarily for three audiences of developers who already know object-oriented programming and are considering using Swift:

- Objective-C programmers who are developing *new* iOS and/or OS X apps and who want to quickly begin using Swift in their apps.
- Objective-C programmers who are enhancing *existing* iOS and/or OS X apps and who want to quickly begin using Swift in their apps.
- Java, C++ and C# programmers who are new to iOS and OS X development and who want to start developing iOS and/or OS X apps in Swift.

Chapters 1 through 12 focus on Swift programming, then Chapters 13 and 14 briefly introduce iOS 8 app development. The iOS 8 chapters are condensed versions of Chapters 2 and 3 of our book, *iOS® 8 for Programmers: An App-Driven Approach with Swift™*, in which we focus on building many complete iPhone® and iPad® apps.¹

We emphasize software engineering best practices. At the heart of the book is the Deitel signature “live-code approach.” Rather than using only code snippets, we present most concepts in the context of complete working Swift programs that run on OS X® and—in the last two chapters—iOS® 8. Each complete code example is accompanied by one or more live sample executions. In the few cases where we use code snippets, we always extract them from compiled, correctly executing, live-code examples. All of the book’s source code is available at

<http://www.deitel.com/books/SwiftFP>

Some complete live-code programs might appear to be code snippets—this is because Swift eliminates various items that are common in many C-based languages, such as the need for a `main` method. For example, the following is actually a complete Swift program:

```
println("Welcome to Swift Programming!")
```

Swift Programming Language

Swift was a surprise announcement at Apple’s WWDC (Worldwide Developer Conference) in June 2014. Because the language is so new, it’s likely to evolve quickly over the next few years. Here’s some key aspects of Swift:

1. Swift is a young language that’s evolving rapidly. We plan to post bonus content covering important new features as they emerge. See <http://www.deitel.com/books/SwiftFP> for details.

- **Apple’s Language of the Future**—Apple is the most valuable technology company in the world, and they’ve declared that Swift is their language of the future for app and systems programming.
- **Popular Language Features**—Swift is a contemporary language with simpler syntax than Objective-C. Because Swift is new, its designers were able to include popular features like those in Objective-C, Java, C#, Ruby, Python and many others. These features (which are listed in Fig. 1.1) include type inference, tuples, closures (lambdas), generics, operator overloading, functions with multiple return values, optionals, String interpolation, switch statement enhancements and more. We’ve found it easier and faster to develop iOS and OS X apps in Swift than in Objective-C.
- **Performance**—Swift was designed for better performance than Objective-C. Apple has observed that Swift code is about 1.5 times faster than Objective-C code on today’s multi-core systems.
- **Error Prevention**—Swift eliminates many common programming errors, making your code more robust and secure. Some of these error prevention features (which are listed in Fig. 1.2) include automatic memory management, no pointers, required braces around every control statement’s body, assignment operators that do not return values, requiring initialization of all variables and constants before they’re used, array bounds checking, automatic checking for overflow of integer calculations, and more.
- **Interoperability with Objective-C**—You can combine Swift and Objective-C in the same app. This enables you to enhance existing Objective-C apps without having to rewrite all the code. Your apps will easily be able to interact with the Cocoa/Cocoa Touch frameworks, which are largely written in Objective-C.
- **Playgrounds**—A playground is an Xcode window in which you can enter Swift code that compiles and executes as you type it. This allows you to see and hear your code’s results as you write it, to quickly find and fix errors, and to experiment with features of Swift and the Cocoa/Cocoa Touch frameworks.

Software Used in Swift for Programmers

To execute our Swift examples and write your own Swift code, you must install Xcode 6, which is available free from the Mac App Store. When you open Xcode for the first time, it will download and install additional features required for development. For the latest information about Xcode, visit

<https://developer.apple.com/xcode>

Swift Fundamentals: Parts I, II and III LiveLessons Video Training

Our *Swift Fundamentals: Parts I, II and III* LiveLessons video training product shows you what you need to know to start building robust, powerful software with Swift. It includes approximately 20 hours of expert training synchronized with *Swift for Programmers*. For additional information about Deitel LiveLessons video products, visit

<http://www.deitel.com/livelessons>

or contact us at deitel@deitel.com.

You also can access our books and LiveLessons videos on Safari Books Online

<http://www.safaribooksonline.com>

if you have an appropriate subscription. A limited free-trial is available. Safari is popular with large companies, colleges, libraries and individuals who would like access to video training and electronic versions of print publications.

Explosive Growth of the iPhone and iPad Is Creating Opportunity for Developers

iPhone and iPad device sales have been growing exponentially, creating significant opportunities for iOS app developers. The first-generation iPhone, released in June 2007, sold 6.1 million units in its initial five quarters of availability.² The iPhone 5s and the iPhone 5c, released simultaneously in September 2013, sold over nine million combined in the first three days of availability.³ The most recent iPhone 6 and iPhone 6 Plus, announced in September 2014, pre-sold four million combined in just one day—double the number of iPhone 5 pre-sales in its first day of pre-order availability.⁴ Apple sold 10 million iPhone 6 and iPhone 6 Plus units combined in their first weekend of availability.⁵

Sales of the iPad are equally impressive. The first generation iPad, launched in April 2010, sold 3 million units in its first 80 days of availability⁶ and over 40 million worldwide by September 2011.⁷ The iPad mini with Retina display (the second-generation iPad mini) and the iPad Air (the fifth-generation iPad) were released in November 2013. In just the first quarter of 2014, Apple sold a record 26 million iPads.⁸

There are over 1.3 million apps in the App Store⁹ and over 75 billion iOS apps have been downloaded.¹⁰ The potential for iOS app developers is enormous. It's likely that most new iOS and OS X development soon will be done in Swift, so there are great opportunities for Swift programmers.

Our Research Sources

Due to Swift's similarities with many of today's popular programming languages, we were able to repurpose and customize examples from many of our other programming textbooks and professional books. Because Swift is new, we performed most of our research using the Apple resources listed on the next page.

-
2. <http://www.apple.com/pr/library/2009/07/21results.html>.
 3. <https://www.apple.com/pr/library/2013/09/23First-Weekend-iPhone-Sales-Top-Nine-Million-Sets-New-Record.html>.
 4. <http://techcrunch.com/2014/09/15/apple-sells-4m-iphone-6-and-6-plus-pre-orders-in-opening-24-hours/>.
 5. <http://www.apple.com/pr/library/2014/09/22First-Weekend-iPhone-Sales-Top-10-Million-Set-New-Record.html>.
 6. <http://www.ipadinsider.com/tag/ipad-sales-figures/>.
 7. <http://www.statista.com/statistics/180656/sales-of-tablets-and-ipads-in-the-us-until-2012/>.
 8. <http://www.theverge.com/2014/1/27/5350106/apple-q1-2014-earnings>.
 9. <http://mashable.com/2014/09/09/apple-1-3-million-apps-app-store/>.
 10. <http://techcrunch.com/2014/06/02/itunes-app-store-now-has-1-2-million-apps-has-seen-75-billion-downloads-to-date/>.

- *The Swift Programming Language*—available in the iBooks store and at:
https://developer.apple.com/library/ios/documentation/Swift/Conceptual/Swift_Programming_Language/
- *Using Swift with Cocoa and Objective-C*—available in the iBooks store and at:
<https://developer.apple.com/library/ios/documentation/Swift/Conceptual/BuildingCocoaApps>
- *The Swift Standard Library Reference*:
<https://developer.apple.com/library/ios/documentation/General/Reference/SwiftStandardLibraryReference>
- The Swift Blog:
<https://developer.apple.com/swift/blog/>
- World Wide Developers Conference (WWDC) 2014 videos:
<https://developer.apple.com/videos/wwdc/2014/>

Teaching Approach

Swift for Programmers contains numerous complete working code examples. We stress program clarity and concentrate on building well-engineered, high-performance software.

Syntax Coloring. For readability, we syntax color all the Swift code, similar to the syntax coloring in the Xcode 6 integrated-development environment. Our conventions are:

comments appear in green
keywords appear in dark blue
constants and literal values appear in light blue
all other code appears in black

Code Highlighting. We place colored rectangles around key code segments.

Using Fonts for Emphasis. We place key terms and the index’s page reference for each term’s defining occurrence in **bold colored** text for easier reference. We emphasize on-screen components in the **bold Helvetica** font (e.g., the **File** menu) and emphasize Swift program text in the **Lucida** font (for example, `println()`).

Objectives/Outline. Each chapter begins with a list of objectives and a chapter outline.

Illustrations/Figures. Abundant tables, programs and program outputs are included.

Programming Tips. We include programming tips to help you focus on important aspects of program development. These tips and practices represent the best we’ve gleaned from a combined eight decades of programming experience.



Good Programming Practices

The Good Programming Practices call attention to techniques that will help you produce programs that are clearer, more understandable and more maintainable.



Common Programming Errors

Pointing out these Common Programming Errors reduces the likelihood that you’ll make them.



Error-Prevention Tips

These tips contain suggestions for exposing bugs and removing them from your programs; many describe aspects of Swift that prevent bugs from getting into programs in the first place.



Performance Tips

These tips highlight opportunities for making your programs run faster or minimizing the amount of memory they occupy.



Software Engineering Observations

The Software Engineering Observations highlight design patterns and architectural issues that affect the construction of software systems, especially large-scale systems.

Index. We've included an extensive index. Each key term's defining occurrence is highlighted with a **bold colored** page number.

Academic Bundle iOS® 8 for Programmers and Swift™ for Programmers

The *Academic Bundle iOS® 8 for Programmers and Swift™ for Programmers* is designed for professionals, students and instructors interested in learning or teaching iOS 8 app development with a broader and deeper treatment of Swift. You can conveniently order the Academic Bundle from pearsonhighered.com with one ISBN: 0-13-408775-5. The Academic Bundle includes:

- *Swift™ for Programmers* (print book)
- *iOS® 8 for Programmers: An App Driven Approach with Swift™, Volume 1, 3/e* (print book)
- Access Code Card for Academic Package to accompany *Swift™ for Programmers*
- Access Code Card for Academic Package to accompany *iOS® 8 for Programmers: An App Driven Approach with Swift™, Volume 1, 3/e*

The two Access Code Cards for the Academic Packages (when used together) give you access to the companion websites, which include self-review questions (with answers), short-answer questions, programming exercises, programming projects and selected videos chosen to get you up to speed quickly with Xcode 6, visual programming and basic Swift-based, iOS 8 programming.

Ordering the Books and Supplements Separately

The print books and Access Code Cards may be purchased separately from pearsonhighered.com using the following ISBNs (email deite1@deite1.com if you have questions):

- *Swift™ for Programmers* (print book): ISBN 0-13-402136-3
- Standalone access code card for Academic Package to accompany *Swift™ for Programmers*: ISBN 0-13-405818-6
- *iOS® 8 for Programmers: An App Driven Approach with Swift™, Volume 1, 3/e* (print book): ISBN 0-13-396526-0
- Standalone access code card for Academic Package to accompany *iOS® 8 for Programmers: An App Driven Approach with Swift™, Volume 1, 3/e*: ISBN 0-13-405825-9

Instructor Supplements

Instructor supplements are available online at Pearson's Instructor Resource Center (IRC). The supplements include:

- Solutions Manual with selected solutions to the short-answer exercises.
- Test Item File of multiple-choice examination questions (with answers).
- PowerPoint® slides with the book's source code and tables.

Please do not write to us requesting access to the Pearson Instructor's Resource Center. Certified instructors who adopt the book for their courses can obtain password access from their regular Pearson sales representatives (www.pearson.com/replocator). Solutions are *not* provided for "project" exercises.

Acknowledgments

Deitel Team

We'd like to thank Abbey Deitel and Barbara Deitel of Deitel & Associates, Inc. for long hours devoted to this project. Abbey co-authored Chapter 1 and this Preface, and she and Barbara painstakingly researched the world of Swift. Our Art Director, Jessica Deitel (age 10) chose the cover color.

Pearson Education Team

We're fortunate to have worked on this project with the dedicated publishing professionals at Prentice Hall/Pearson. We appreciate the extraordinary efforts and 20-year mentorship of our friend and professional colleague Mark L. Taub, Editor-in-Chief of Pearson Technology Group. Kim Boedigheimer recruited distinguished members of the iOS, OS X and emerging Swift communities to review the manuscript and she managed the review process. We selected the cover art and Chuti Prasertsith designed the cover. John Fuller managed the book's production.

Reviewers

We wish to acknowledge the efforts of our reviewers. They scrutinized the text and the programs and provided countless suggestions for improving the presentation.

- Scott Bossack, Lead iOS Developer, Thrillist Media Group
- René Cacheaux, iOS Architect, Mutual Mobile
- Ash Furrow, iOS Developer, Artsy
- Rob McGovern, Independent Contractor
- Abizer Nasir, Freelance iOS and OS X Developer, Jungle Candy Software Ltd.
- Rik Watson, Technical Team Lead for HP Enterprise Services (Applications Services)
- Jack Watson-Hamblin, Programming Writer and Teacher, MotionInMotion (<https://motioninmotion.tv/>)

A Special Thank You to Reviewer Charles Brown

When Swift was announced in June 2014, within days our publisher, Prentice Hall/Pearson, agreed to publish our Swift book, which at the time was just an idea. One key prob-

lem—where would we find Swift reviewers when the language was so new? We asked for help from our 75,000 social media and newsletter followers. Charles E. Brown, Independent Contractor affiliated with Apple and Adobe, was the first to respond and became the core member of our review team. He mentored us throughout the project, providing insights, encouragement, answers to our technical questions and appropriate cautions.

Keeping in Touch with the Authors

As you read the book, if you have questions, comments or suggestions, send an e-mail to us at

`deitel@deitel.com`

and we'll respond promptly. For updates on this book, visit

`http://www.deitel.com/books/SwiftFP`

subscribe to the *Deitel*[®] *Buzz Online* newsletter at

`http://www.deitel.com/newsletter/subscribe.html`

and join the Deitel social networking communities on

- Facebook[®] (<http://facebook.com/DeitelFan>)
- Twitter[®] (@deitel)
- Google+[™] (<http://google.com/+DeitelFan>)
- YouTube[®] (<http://youtube.com/DeitelTV>)
- LinkedIn[®] (<http://linkedin.com/company/deitel-&-associates>)

Well, there you have it! As you read the book, we'd appreciate your comments, criticisms, corrections and suggestions for improvement. Please address all correspondence to:

`deitel@deitel.com`

We'll respond promptly. We hope you enjoy working with *Swift for Programmers* as much as we enjoyed writing it!

Paul and Harvey Deitel

About the Authors

Paul Deitel, CEO and Chief Technical Officer of Deitel & Associates, Inc., is a graduate of MIT, where he studied Information Technology. He holds the Java Certified Programmer and Java Certified Developer designations, and is an Oracle Java Champion. Paul was also named as a Microsoft[®] Most Valuable Professional (MVP) for C# in 2012–2014. Through Deitel & Associates, Inc., he has delivered hundreds of programming courses worldwide to clients, including Cisco, IBM, Siemens, Sun Microsystems (now Oracle), Dell, Fidelity, NASA at the Kennedy Space Center, the National Severe Storm Laboratory, White Sands Missile Range, Rogue Wave Software, Boeing, SunGard, Nortel Networks, Puma, iRobot, Invensys and many more. He and his co-author, Dr. Harvey M. Deitel, are the world's best-selling programming-language textbook/professional book/video authors.

Dr. Harvey Deitel, Chairman and Chief Strategy Officer of Deitel & Associates, Inc., has over 50 years of experience in the computer field. Dr. Deitel earned B.S. and M.S. degrees in Electrical Engineering from MIT and a Ph.D. in Mathematics from Boston University. He has extensive college teaching experience, including earning tenure and serving as the Chairman of the Computer Science Department at Boston College before founding Deitel & Associates, Inc., in 1991 with his son, Paul. The Deitels' publications have earned international recognition, with translations published in Japanese, German, Russian, Spanish, French, Polish, Italian, Simplified Chinese, Traditional Chinese, Korean, Portuguese, Greek, Urdu and Turkish. Dr. Deitel has delivered hundreds of programming courses to corporate, academic, government and military clients.

About Deitel® & Associates, Inc.

Deitel & Associates, Inc., founded by Paul Deitel and Harvey Deitel, is an internationally recognized authoring and corporate training organization, specializing in mobile app development, computer programming languages, object technology and Internet and web software technology. The company's training clients include many of the world's largest companies, government agencies, branches of the military and academic institutions. The company offers instructor-led training courses delivered at client sites worldwide on major programming languages and platforms, including Swift and iOS app development, Java™, Android app development, C++, C, Visual C#®, Visual Basic®, Python®, object technology, Internet and web programming and a growing list of additional programming and software development courses.

Through its 39-year publishing partnership with Pearson/Prentice Hall, Deitel & Associates, Inc., publishes leading-edge programming textbooks and professional books in print and a wide range of e-book formats, and *LiveLessons* video courses. Deitel & Associates, Inc. and the authors can be reached at:

deitel@deitel.com

To learn more about Deitel's *Dive-Into*® *Series* Corporate Training curriculum, visit:

<http://www.deitel.com/training>

To request a proposal for worldwide on-site, instructor-led training at your organization, e-mail deitel@deitel.com.

Individuals wishing to purchase Deitel books and *LiveLessons* video training can do so through www.deitel.com. Bulk orders by corporations, the government, the military and academic institutions should be placed directly with Pearson. For more information, visit

<http://www.informit.com/store/sales.aspx>



Before You Begin

This section contains information you should review before using this book. Updates to the information presented here will be posted at:

<http://www.deitel.com/books/SwiftFP>

Conventions

Font and Naming

We use fonts to distinguish between on-screen components (such as menu names and menu items) and Swift code or commands. Our convention is to emphasize on-screen components in a sans-serif bold **Helvetica** font (for example, **File** menu) and to emphasize Swift code and commands in a sans-serif **Lucida** font (for example, `println()`). When building user interfaces (UIs) using Xcode's Interface Builder, we also use the bold **Helvetica** font to refer to property names for UI components (such as a **Label**'s **Text** property).

Conventions for Referencing Menu Items in a Menu

We use the > character to indicate selecting a menu item from a menu. The notation **File > Open...** indicates that you should select the **Open...** menu item from the **File** menu.

Software Used in this Book

To execute our Swift examples and write your own Swift code, you must install Xcode 6. You can install the currently released Xcode version for free from the Mac App Store. When you open Xcode for the first time, it will download and install additional features required for development. For the latest information about Xcode, visit

<https://developer.apple.com/xcode>

A Note Regarding the Xcode 6 Toolbar Icons

We developed this book's examples with Xcode 6 on OS X Yosemite. If you're running OS X Mavericks, some Xcode toolbar icons we show in the text may differ on your screen.

Becoming a Registered Apple Developer

Registered developers have access to the online iOS and OS X documentation and other resources. Apple also now makes Xcode pre-release versions (such as the next point release or major version) available to all registered Apple developers. To register, visit:

<https://developer.apple.com/register>

To download the next pre-release Xcode version, visit:

```
https://developer.apple.com/xcode/downloads
```

Once you download a prerelease DMG (disk image) file, double click it to launch the installer, then follow the on-screen instructions.

Fee-Based iOS Developer Programs

In Chapters 13–14, you’ll build two iOS apps and test them on your Mac using the iOS simulator that’s bundled with Xcode. If you’d like to run iOS apps on actual iOS devices, you must be a member of one of the following iOS developer programs.

iOS Developer Program

The fee-based **iOS Developer Program** allows you to load your iOS apps onto iOS devices for testing and to submit your apps to the App Store. If you intend to distribute iOS apps, you’ll need to join the fee-based program. You can sign up at

```
https://developer.apple.com/programs
```

iOS Developer Enterprise Program

Organizations may register for the iOS Developer Enterprise Program at

```
https://developer.apple.com/programs/ios/enterprise
```

which enables developers to deploy proprietary iOS apps to employees within their organization.

iOS Developer University Program

Colleges and universities interested in offering iOS app-development courses can apply to the iOS Developer University Program at

```
https://developer.apple.com/programs/ios/university
```

Qualifying schools receive free access to all the developer tools and resources. Students can share their apps with each other and test them on iOS devices.

Adding Your Paid iOS Developer Program Account to Xcode

Xcode can interact with your paid iOS and OS X Developer Program accounts on your behalf so that you can install apps onto your iOS devices for testing. If you have a paid iOS Developer Program account, you can add it to Xcode. To do so:

1. Select **Xcode > Preferences...**
2. In the **Accounts** tab, click the + button in the lower left corner and select **Add Apple ID...**
3. Enter your Apple ID and password, then click **Add**.

Obtaining the Code Examples

The *Swift for Programmers* examples are available for download as a ZIP file from

```
http://www.deitel.com/books/SwiftFP
```

under the heading **Download Code Examples and Other Premium Content**. When you click the link to the ZIP file, it will be placed by default in your user account's **Downloads** folder. We assume that the examples are located in the `SwiftFPEExamples` folder in your user account's **Documents** folder. You can use Finder to move the ZIP file there, then double click the file to extract its contents.

Xcode Playgrounds and Projects for the Code Examples

Playgrounds are a new interactive coding capability in Xcode 6. They execute Swift code as you write it. They're particularly useful for learning and experimenting with Swift or the Cocoa and Cocoa Touch frameworks that are used to build iOS and OS X apps. Projects, on the other hand, are used to manage all the files for each app that you create.

For each example, we provide one of the following:

- an Xcode playground file with the `.playground` extension
- an Xcode project for an OS X **Command Line Tool** app that produces text output (such projects don't require you to develop a GUI or to run apps in the iOS simulator)
- an Xcode project for an iOS 8 app that runs in the iOS simulator bundled with Xcode.

An Xcode project is stored in a folder with the project's name. In that folder is a file with a `.xcodeproj` extension. You can double click a `.playground` or `.xcodeproj` file to open it in Xcode. Throughout this book, we use playgrounds for single-source-file examples and projects for multi-source-file examples.

Use Playgrounds for Learning

We recommend that as you learn Swift, you enter each example's code into an Xcode 6 playground so that you can immediately see the code in action as you write it. Sometimes you might need to restart the IDE if a playground stops working correctly. If you enter any of our multi-source-file examples into a playground, you must define any functions and types *before* they're used.

Viewing Output in a Playground

In a playground, the results of any output statements are visible only if the **Assistant Editor** is displayed. To open it in a playground, select **Assistant Editor > Show Assistant Editor** from Xcode's **View** menu. The **Assistant Editor** will appear at the playground window's right side.

Playground and Project Naming Conventions

Each project or playground is named based on its figure number(s) or the concept being presented. The comment in the first line of a source code file contains information to help you identify which playground or project to open from the chapter's examples folder:

- the project's or playground's base name—e.g., `fig02-01` and `fig03-01-11` correspond to `fig02-01.playground` and `fig03-01-11.xcodeproj`, respectively.
- the project's or playground's complete name—e.g., `CompoundInterest.playground` or `Inheritance.xcodeproj`.

Configuring Xcode to Display Line Numbers

Many programmers find it helpful to display line numbers in the code editor. To do so:

1. Open Xcode and select **Preferences...** from the **Xcode** menu.
2. Select the **Text Editing** tab, then ensure that the **Editing** subtab is selected.
3. Check the **Line Numbers** checkbox.

You're now ready to begin learning Swift with *Swift for Programmers*. We hope you enjoy the book! If you have any questions, please email us at deitel@deitel.com.

5

Functions and Methods: A Deeper Look; enums and Tuples

Objectives

In this chapter you'll:

- Learn about Swift modules (for software reuse).
- Define functions with multiple parameters.
- Use random-number generation to implement a game-playing app.
- Use `enum` types to create sets of named constants.
- Return multiple values from a function via a tuple, pass a tuple to a function and access a tuple's elements.
- Learn how an identifier's scope limits its visibility to specific parts of a program.
- Create overloaded functions.
- Learn how local and external parameter names are used in function and method calls.
- Use default parameter values in function calls.
- Pass method arguments by value and by reference.
- Define a recursive function.
- Define a nested function.

5.1	Introduction	5.7	Scope of Declarations
5.2	Modules in Swift	5.8	Function and Method Overloading
5.3	Darwin Module—Using Predefined C Functions	5.9	External Parameter Names
5.4	Multiple-Parameter Function Definition	5.10	Default Parameter Values
5.5	Random-Number Generation	5.11	Passing Arguments by Value or by Reference
5.6	Introducing Enumerations and Tuples	5.12	Recursion
5.6.1	Introducing Enumeration (enum) Types	5.13	Nested Functions
5.6.2	Tuples and Multiple Function Return Values	5.14	Wrap-Up
5.6.3	Tuples as Function Arguments		
5.6.4	Accessing the Raw Value of an enum Constant		

5.1 Introduction

We introduced functions and methods in Chapter 3. The key distinction between a function and a method is that any function defined *in a type* is a method.

In this chapter, we begin by discussing modules, which Swift uses to package related software components for reuse. We introduce Darwin—Apple’s UNIX-based core of OS X and iOS—and import Darwin features (such as a C-based random-number-generation function) for use in apps.

We discuss random-number generation and develop a version of a popular casino dice game. That example demonstrates basic enum types for creating named constants that improve the readability of the code. You’ll see that Swift’s enum constants can have values, but that’s not required. The example also presents tuples—collections of values of the same or different types. We return multiple values from a function via a tuple, pass a tuple to a function and access a tuple’s elements via both names and indices.

Next, we discuss Swift’s scope rules. Then, we introduce the concept of *overloading*. You’ll frequently see identically named functions or, within a type, identically named methods. This overloading is used to implement functions or methods that perform similar tasks but with different types and/or different numbers of parameters. This chapter demonstrates overloading with functions, and you’ll see examples of method overloading in later chapters.

We discuss the differences between calling functions and methods and present the concepts of local vs. external parameter names. As you’ll see, external parameter names must be used in a function call to label all of the corresponding arguments. This is another distinction between functions and methods—by default, methods require their second and subsequent arguments to be labeled with parameter names. This has to do with the similarities between how methods are named in Objective-C and Swift, which we discuss in Section 5.9. We also mention how to disable this feature when calling methods. Parameter names are always required in initializer calls.

We use a default parameter value that the compiler inserts in a function call if you do not provide the corresponding argument when the function is called. We discuss how value- and reference-type arguments are passed to methods, then demonstrate how to pass

arguments by reference using the keyword `inout`. You'll write recursive functions (functions that call themselves) and nested functions.

Many of the features presented as functions in this chapter also apply to methods and initializers in the new types you create. We'll point out key differences between functions, methods and initializers.

5.2 Modules in Swift

Swift apps are written by combining new functions and types, properties, methods, classes, structs (Chapter 9) and enums (introduced in Section 5.6 and discussed in more detail in Chapter 9) with predefined capabilities in the Swift Standard Library, the Cocoa and Cocoa Touch frameworks, and other class libraries. Figure 5.1 overviews some functions, types and protocols (similar to interfaces in other languages) from the Swift Standard Library. You can locate additional information about Swift Standard Library types and functions in the *Swift Standard Library Reference* at

<http://bit.ly/SwiftStandardLibrary>

At the time of this writing, the *Swift Standard Library Reference* is not yet complete. There are many other built-in free functions (sometimes called global functions), but only a few are currently listed. Similarly, there are other protocols not yet included in the reference, but mentioned in other Swift documentation (e.g., `Hashable` and `DebugPrintable`).

Feature	Description
<i>Types</i>	
Array	This type is used to represent arrays—collections of related data items. Type <code>Array</code> provides many initializers, properties, methods and operators for performing common array manipulations. Chapter 6 discusses type <code>Array</code> in detail.
Dictionary	A <code>Dictionary</code> maps unique <i>keys</i> to <i>values</i> —for example, an employee's ID number can be mapped to one employee's information. Type <code>Dictionary</code> provides many initializers, properties, methods and operators for performing common manipulations of key–value pairs. Chapter 7 discusses type <code>Dictionary</code> in detail.
Boolean and numeric types	As you've seen, Swift provides type <code>Bool</code> and integer and floating-point numeric types (Fig. 2.6). These are the equivalent of what many programming languages refer to as the built-in, primitive or fundamental types.
String	Strings are collections of characters. Type <code>String</code> provides many initializers, properties, methods and operators for performing common <code>String</code> manipulations. We present details of type <code>String</code> throughout the book.
<i>Protocols</i>	
<code>Comparable</code>	An item that is <code>Comparable</code> can be compared with another item of the same type using the <code><</code> operator. Strings and all of Swift's integer and floating-point numeric types are <code>Comparable</code> . We discuss how to make your own types <code>Comparable</code> in Chapter 12, Operator Overloading and Subscripts.

Fig. 5.1 | Some Swift Standard Library features, (Part 1 of 2.)

Feature	Description
Equatable	An item that is Equatable can be compared with another item of the same type using the == operator. Booleans, Strings and all of Swift's numeric types are Equatable. We discuss how to make your own types Equatable in Chapter 12.
Printable	Any item that is Printable has a description property that returns a String representation of the item—similar to some languages' toString or ToString methods. Booleans, Strings and all of Swift's numeric types are Printable. We discuss how to make your own types Printable in Chapter 10.
<i>Functions</i>	
print, println	Functions that display text representations of Printable items.
sort, sorted	Functions that sort the contents of Arrays—sort modifies the original Array's contents and sorted returns a new Array containing the sorted contents. Chapter 6 uses these functions to sort Arrays.

Fig. 5.1 | Some Swift Standard Library features, (Part 2 of 2.)

Modules

Related software components in Objective-C are grouped into frameworks (similar to namespaces or packages in other languages) so that they can be reused in Cocoa and Cocoa Touch apps. Swift's equivalent to a framework is a **module**. When you create a Swift project, Xcode places all of the project's Swift code in a module with the same name as your project. If you create a Swift-based Cocoa Framework project or Cocoa Touch Framework project, you can then reuse that framework in Cocoa and Cocoa Touch apps by importing it with the `import` keyword (as you did with the Foundation framework in Fig. 3.6).



Software Engineering Observation 5.1

Don't try to "reinvent the wheel." When possible, reuse capabilities of the Swift Standard Library, the Cocoa and Cocoa Touch frameworks, and other libraries. This reduces app development time, avoids introducing programming errors and contributes to good app performance.

5.3 Darwin Module—Using Predefined C Functions

Just as your Swift apps can reuse Cocoa and Cocoa Touch frameworks (written largely in Objective-C), they can also reuse C-based UNIX functions (such as `arc4random_uniform` in Section 5.5) and C Standard Library functions (such as the common C math functions listed in Fig. 5.2) that are built into OS X and iOS. These and many other features of UNIX and C are available via the **Darwin module**, which provides access to the C libraries in Darwin—Apple's open-source UNIX-based core on which the OS X and iOS operating systems are built. To import the Darwin module, use the following `import` declaration:

```
import Darwin
```

The Darwin module is imported by default into several Cocoa and Cocoa Touch frameworks—such as Foundation, AppKit and UIKit—so that various software components in those frameworks can interact with the underlying operating system.

Method	Description	Example
<i>Throughout this table, x and y are of type <code>Double</code></i>		
<code>abs(x)</code>	absolute value of x	<code>abs(23.7)</code> is 23.7 <code>abs(0.0)</code> is 0.0 <code>abs(-23.7)</code> is 23.7
<code>ceil(x)</code>	rounds x to the smallest integer not less than x	<code>ceil(9.2)</code> is 10.0 <code>ceil(-9.8)</code> is -9.0
<code>cos(x)</code>	trigonometric cosine of x (x in radians)	<code>cos(0.0)</code> is 1.0
<code>exp(x)</code>	exponential method e^x	<code>exp(1.0)</code> is 2.71828 <code>exp(2.0)</code> is 7.38906
<code>floor(x)</code>	rounds x to the largest integer not greater than x	<code>floor(9.2)</code> is 9.0 <code>floor(-9.8)</code> is -10.0
<code>log(x)</code>	natural logarithm of x (base e)	<code>log(M_E)</code> is 1.0 <code>log(M_E * M_E)</code> is 2.0
<code>max(x, y)</code>	larger value of x and y	<code>max(2.3, 12.7)</code> is 12.7 <code>max(-2.3, -12.7)</code> is -2.3
<code>min(x, y)</code>	smaller value of x and y	<code>min(2.3, 12.7)</code> is 2.3 <code>min(-2.3, -12.7)</code> is -12.7
<code>pow(x, y)</code>	x raised to the power y (i.e., x^y)	<code>pow(2.0, 7.0)</code> is 128.0 <code>pow(9.0, 0.5)</code> is 3.0
<code>sin(x)</code>	trigonometric sine of x (x in radians)	<code>sin(0.0)</code> is 0.0
<code>sqrt(x)</code>	square root of x	<code>sqrt(900.0)</code> is 30.0
<code>tan(x)</code>	trigonometric tangent of x (x in radians)	<code>tan(0.0)</code> is 0.0

Fig. 5.2 | Some math functions from the C Standard Library.

5.4 Multiple-Parameter Function Definition

In previous chapters, you called functions, methods and initializers with varying numbers of arguments. You also defined functions and methods with only one parameter. In this section, we define and call a function with multiple parameters.

Figure 5.3 defines a function `maximum` (lines 4–18) that determines and returns the largest of three `Double` values. Lines 21–23 call `maximum` with the largest value (3.3) as the first, second or third argument, respectively, to show that the function always returns the largest of its three arguments.

```

1 // fig05-03: Function maximum with three Double parameters.
2
3 // returns the maximum of its three Double parameters
4 func maximum(x: Double, y: Double, z: Double) -> Double {
5     var maximumValue = x // assume x is the largest to start
6

```

Fig. 5.3 | Function `maximum` with three `Double` parameters. (Part I of 2.)

```

7 // determine whether y is greater than maximumValue
8 if y > maximumValue {
9     maximumValue = y
10 }
11
12 // determine whether z is greater than maximumValue
13 if z > maximumValue {
14     maximumValue = z
15 }
16
17 return maximumValue;
18 }
19
20 // test function maximum
21 println("Maximum of 3.3, 2.2 and 1.1 is: \(\maximum(3.3, 2.2, 1.1)\)")
22 println("Maximum of 1.1, 3.3 and 2.2 is: \(\maximum(1.1, 3.3, 2.2)\)")
23 println("Maximum of 2.2, 1.1 and 3.3 is: \(\maximum(2.2, 1.1, 3.3)\)")

```

```

Maximum of 3.3, 2.2 and 1.1 is: 3.3
Maximum of 1.1, 3.3 and 2.2 is: 3.3
Maximum of 2.2, 1.1 and 3.3 is: 3.3

```

Fig. 5.3 | Function `maximum` with three `Double` parameters. (Part 2 of 2.)

Function maximum

Line 4 indicates that `maximum` requires three `Double` parameters (`x`, `y` and `z`) to accomplish its task and returns a `Double`. There must be one argument in the function call for each parameter in the function definition. Also, each argument must match the type of the corresponding parameter. Parameters are *constants* by default—if you need to modify a parameter’s value in the function’s body, you must place `var` before the parameter’s name.



Common Programming Error 5.1

Declaring method parameters of the same type as `x`, `y`: `Double` instead of `x: Double`, `y: Double` is a syntax error—a type is required for each parameter in the parameter list.



Error-Prevention Tip 5.1

Making parameters constant by default ensures that you do not accidentally modify their values—you must explicitly opt for this functionality by declaring parameters as `var`.

Three Ways to Return Control from a Function

There are three ways to return control to the statement that calls a function. If the function’s return type is `Void` (that is, it does not return a result), control returns when the function-ending right brace is reached or when the statement

```
return
```

is executed from the function’s body. If the function returns a result, the statement

```
return expression
```

evaluates the *expression*, then returns the result (and control) to the caller (as in line 17).

Swift Function `max`

Swift provides a `max` function that can be used to compare two values of the same `Comparable` type—all of Swift’s numeric types and `Strings` are `Comparable`. A second version of `max` takes a variable number of arguments and is used to compare three or more arguments of the same `Comparable` type. You’ll create your own functions with variable-length parameter lists in Chapter 6, Arrays and an Introduction to Closures. There is no need for us to define our own maximum function, as we could have replaced the `maximum` calls in lines 21–23 with:

```
max(3.3, 2.2, 1.1)
max(1.1, 3.3, 2.2)
max(2.2, 1.1, 3.3)
```

5.5 Random-Number Generation

We now take a brief diversion into a popular type of programming application—simulation and game playing. In this and the next section, we develop a game-playing program with multiple functions.

The element of chance can be introduced in a program via the `arc4random_uniform` function (a C-based UNIX function from the Darwin module), which produces random unsigned 32-bit integers (`UInt32`; see Fig. 2.6) from 0 up to but not including an upper bound that you specify as an argument. There’s also function `arc4random`, which takes no arguments and returns a random unsigned 32-bit integer in the range 0 (`UInt32.min`) to 4,294,967,295 (`UInt32.max`).

Both functions use the RC4 (also called ARCFOUR) random-number generation algorithm (<http://en.wikipedia.org/wiki/RC4>) and produce **nondeterministic random numbers** that cannot be predicted. To use these functions, you must import the Darwin module (Section 5.3).



Error-Prevention Tip 5.2

Functions `arc4random_uniform` and `arc4random` cannot produce repeatable random-number sequences. If you require repeatability for testing, use the Darwin module’s C function `random` to obtain the random values and function `srandom` to seed the random-number generator with the same seed during each program execution. Once you’ve completed testing, use either `arc4random_uniform` or `arc4random` to produce random values.

Obtaining a Random Value with `arc4random`

The following statement generates a random `UInt32` value in the range 0 (`UInt32.min`) to 4,294,967,295 (`UInt32.max`):

```
let randomValue = arc4random()
```

Obtaining a Random Value in a Specific Range with `arc4random_uniform`

The range of values produced by `arc4random` generally differs from the range of values required in a particular app. For example, a program that simulates the rolling of a six-sided die might require random integers in the range 1–6. For cases like this, we’ll use the function `arc4random_uniform`.

To demonstrate `arc4random_uniform`, let’s develop a program that simulates 20 rolls of a six-sided die and displays the value of each roll. First, we use `arc4random_uniform` to produce random values in the range 0–5, as follows:

```
let face = arc4random_uniform(6)
```

The argument 6 is the upper bound of the values produced and represents the number of unique values to produce (in this case six—0, 1, 2, 3, 4 and 5).

A six-sided die has the numbers 1–6 on its faces, not 0–5. So we shift the range of numbers produced by adding 1 to our previous result, as in

```
let face = 1 + arc4random_uniform(6)
```

Rolling a Six-Sided Die 20 Times

Figure 5.4 shows two sample outputs which confirm that the results of the preceding calculation are integers in the range 1–6, and that each run of the program can produce a *different* sequence of random numbers. Line 2 imports the Darwin module to allow the program to access function `arc4random_uniform`—the Swift Standard Library does not have its own random-number-generation capabilities. Line 5 executes 20 times in a loop to roll the die. To run the program multiple times in a playground, simply press *Enter* on a blank line.

```
1 // fig05-04: Shifted and scaled random integers
2 import Darwin // allow program to use C function arc4random_uniform
3
4 for i in 1...20 {
5     print("\(1 + arc4random_uniform(6)) ")
6 }
```

```
3 3 3 1 1 2 1 2 4 2 2 3 6 2 5 3 4 6 6 1
```

```
6 2 5 1 3 5 2 1 6 5 4 1 6 1 3 3 1 4 3 4
```

Fig. 5.4 | Shifted and scaled random integers.

5.6 Introducing Enumerations and Tuples

One popular game of chance is the dice game known as “craps.” In this section, we implement a simple version of the game and introduce Swift’s `enum` and `tuple` features.

The rules of the game are straightforward:

You roll two dice. Each die has six faces, which contain one, two, three, four, five and six spots, respectively. After the dice have come to rest, the sum of the spots on the two upward faces is calculated. If the sum is 7 or 11 on the first throw, you win. If the sum is 2, 3 or 12 on the first throw (called “craps”), you lose (i.e., “the house” wins). If the sum is 4, 5, 6, 8, 9 or 10 on the first throw, that sum becomes your “point.” To win, you must continue rolling the dice until you “make your point” (i.e., roll that same point value). You lose by rolling a 7 before making your point.

The app in Fig. 5.5 simulates the game of craps. Lines 31–74 of the program play the game. The `rollDice` function (lines 19–23) is called to roll the two dice and compute their sum, and the `displayRoll` function (lines 26–28) is called to display the results of a roll. The four sample outputs show winning on the first roll, losing on the first roll, winning on a subsequent roll and losing on a subsequent roll, respectively.

```

1 // fig05-05: Simulating the dice game craps
2 import Darwin
3
4 // enum representing game status constants (no raw type)
5 enum Status {
6     case Continue, Won, Lost
7 }
8
9 // enum with Int constants representing common dice totals
10 enum DiceNames: Int {
11     case SnakeEyes = 2
12     case Trey = 3
13     case Seven = 7
14     case YoLeven = 11
15     case BoxCars = 12
16 }
17
18 // function that rolls two dice and returns them and their sum as a tuple
19 func rollDice() -> (die1: Int, die2: Int, sum: Int) {
20     let die1 = Int(1 + arc4random_uniform(6)) // first die roll
21     let die2 = Int(1 + arc4random_uniform(6)) // second die roll
22     return (die1, die2, die1 + die2)
23 }
24
25 // function to display a roll of the dice
26 func displayRoll(roll: (Int, Int, Int)) {
27     println("Player rolled \(roll.0) + \(roll.1) = \(roll.2)")
28 }
29
30 // play one game of craps
31 var myPoint = 0 // point if no win or loss on first roll
32 var gameStatus = Status.Continue // can contain Continue, Won or Lost
33
34 var roll = rollDice() // first roll of the dice
35 displayRoll(roll) // display the two dice and the sum
36
37 // determine game status and point based on first roll
38 switch roll.sum {
39     // win on first roll
40     case DiceNames.Seven.rawValue, DiceNames.YoLeven.rawValue:
41         gameStatus = Status.Won
42     // lose on first roll
43     case DiceNames.SnakeEyes.rawValue, DiceNames.Trey.rawValue,
44         DiceNames.BoxCars.rawValue:
45         gameStatus = Status.Lost
46     // did not win or lose, so remember point
47     default:
48         gameStatus = Status.Continue // game is not over
49         myPoint = roll.sum // remember the point
50         println("Point is \(myPoint)")
51 }
52

```

Fig. 5.5 | Simulating the dice game craps. (Part I of 2.)

```

53 // while game is not complete
54 while gameStatus == Status.Continue
55 {
56     roll = rollDice() // first roll of the dice
57     displayRoll(roll) // display the two dice and the sum
58
59     // determine game status
60     if roll.sum == myPoint { // won by making point
61         gameStatus = Status.Won
62     } else {
63         if (roll.sum == DiceNames.Seven.rawValue) { // lost by rolling 7
64             gameStatus = Status.Lost
65         }
66     }
67 }
68
69 // display won or lost message
70 if gameStatus == Status.Won {
71     println("Player wins")
72 } else {
73     println("Player loses")
74 }

```

```

Player rolled 2 + 5 = 7
Player wins

```

```

Player rolled 2 + 1 = 3
Player loses

```

```

Player rolled 2 + 4 = 6
Point is 6
Player rolled 3 + 1 = 4
Player rolled 5 + 5 = 10
Player rolled 6 + 1 = 7
Player loses

```

```

Player rolled 4 + 6 = 10
Point is 10
Player rolled 1 + 3 = 4
Player rolled 1 + 3 = 4
Player rolled 2 + 3 = 5
Player rolled 4 + 4 = 8
Player rolled 6 + 6 = 12
Player rolled 4 + 4 = 8
Player rolled 4 + 5 = 9
Player rolled 2 + 6 = 8
Player rolled 6 + 6 = 12
Player rolled 6 + 4 = 10
Player wins

```

Fig. 5.5 | Simulating the dice game craps. (Part 2 of 2.)

The Game’s Logic

The game is reasonably involved. The player may win or lose on the first roll, or may win or lose on any subsequent roll. Lines 31–74 contain the logic for one complete game of craps. Variable `myPoint` (line 31) stores the “point” if the player does not win or lose on the first roll. Variable `gameStatus` (line 32) maintains the game status. Variable `roll` (created at line 34 and assigned a new value at line 56) stores the most recent roll of the dice. Variable `myPoint` is initialized to 0 so the program can compile. If you do not initialize `myPoint`, the compiler issues an error, because `myPoint` is not assigned a value in every case of the `switch` statement—thus, the app could try to use `myPoint` before it’s assigned a value. By contrast, `gameStatus` does not require initialization because it’s assigned a value in every branch of the `switch` statement—thus, it’s guaranteed to be initialized before it’s used.



Error-Prevention Tip 5.3

Initialize every variable when it’s defined.

The First Roll

Line 34 calls function `rollDice`, which picks two random values from 1 to 6 and returns both values and their sum. Line 35 calls function `displayRoll` to display the value of the first die, the value of the second die and the sum of the dice. We explain the details of `rollDice`’s return value and `displayRoll`’s argument in Sections 5.6.2 and 5.6.3, respectively. Next, the program enters the `switch` statement at lines 38–51, which uses the sum of the dice to determine whether the game has been won or lost, or whether it should continue with another roll.

Additional Rolls of the Dice

If we’re still trying to “make our point” (i.e., the game is continuing from a prior roll), the loop in lines 54–67 executes. Line 56 rolls the dice again. Lines 60–66 determine whether the game was won or lost on the most recent roll—if not, the game continues. When the game completes, lines 70–74 display a message indicating whether the player won or lost, and the app terminates.

5.6.1 Introducing Enumeration (enum) Types

In this section, we introduce basic enumeration features—more details are presented in Chapter 9, Structures, Enumerations and Nested Types.

Status Enumeration

The `Status` type (lines 5–7) is an **enumeration** that declares a set of constants represented by identifiers. An enumeration is introduced by the keyword `enum` and a type name (in this case, `Status`). As with a class, braces (`{` and `}`) delimit the `enum`’s body. Inside the braces is a case containing a comma-separated list of **enumeration constants**. The `enum` constant names must be unique. Unlike `enums` in other C-based programming languages, a Swift `enum`’s constants do not have values by default—the constants themselves are the values. Sometimes it’s useful for each constant to have a so-called raw value, as in the `DiceNames` `enum` (lines 10–16) that we discuss momentarily.

Variables and constants of type `Status` can be assigned only constants defined in the `Status` enum. When the game is won, the app sets variable `gameStatus` to `Status.Won` (lines 41 and 61). When the game is lost, the app sets `gameStatus` to `Status.Lost` (lines 45 and 64). Otherwise, the app sets `gameStatus` to `Status.Continue` (line 48) to indicate that the dice must be rolled again. If a variable has an enum type, you can assign enum constants to the variable using the shorthand notation:

```
variableName = .EnumConstantName
```



Good Programming Practice 5.1

enum constant names should begin with a capital letter and use camel-case naming.

DiceNames Enumeration

The sums of the dice that would result in a win or loss on the first roll are declared in the `DiceNames` enumeration in lines 10–16. These are used in the cases of the `switch` statement (lines 38–51). The identifier names use casino parlance—such as `snake eyes` (2) and `box cars` (12)—for these sums. In `DiceNames` we explicitly assign a value to each constant’s name. When an enum’s constants require values (known as **raw values**), you must specify the enum’s **raw type**—that is, the type used to represent each constant’s value. Line 10 indicates that `DiceNames`’s raw type is `Int`, so each constant’s type is also `Int`. The raw type can be any of Swift’s numeric types, type `String` or type `Character`.

Constants that are assigned explicit values are typically defined in a separate cases for readability (as in lines 11–15), but this is not required. We could have written the `DiceNames` enumeration as:

```
enum DiceNames: Int {
    case SnakeEyes = 2, Trey = 3, Seven = 7, YoLeven = 11,
        BoxCars = 12
}
```

If an enum type’s constants represent sequential integer values, they can be defined as a comma-separated list in one case, as in:

```
enum Months: Int {
    case January = 1, February, March, April, May, June, July,
        August, September, October, November, December
}
```

In `Months`, each subsequent constant after `January` has a value one higher than the value of the previous constant, so `February` is 2, `March` is 3, etc. So, we could have defined the `DiceNames` constants `SnakeEyes` and `Trey` in one case as:

```
case SnakeEyes = 2, Trey
```

The raw values of an enum’s constants must be unique. In an enum with one of the integer numeric types, if the first constant is unassigned, the compiler gives it the value 0.



Good Programming Practice 5.2

Using enumeration constants (like `Months.January`, `Months.February`, etc.) rather than literal integer values (such as 1, 2, etc.) makes code easier to read and maintain.

5.6.2 Tuples and Multiple Function Return Values

In the rules of the game, the player must roll two dice on the first roll and must do the same on all subsequent rolls. Function `rollDice` (lines 19–23) rolls the dice and computes their sum. Function `rollDice` is declared once, but it’s called from two places (lines 34 and 56). The function takes no arguments. Each time it’s called, `rollDice` returns *three values* (the two die values and the sum of the dice) as a **tuple**—an arbitrary collection of values that can be of the same or different types. In function `rollDice`’s return type

```
(die1: Int, die2: Int, sum: Int)
```

`die1`, `die2` and `sum` are names that can be used to access the returned tuple’s elements.



Good Programming Practice 5.3

You’re not required to specify names for each element of a tuple, but doing so makes the code more readable.

The sum of the dice can be calculated using the values of the tuple elements `die1` and `die2`. We chose to include `sum` in the tuple because there are multiple locations in the program where we use the sum of the dice. Rather than recalculating the sum each time, we calculate it once in `rollDice`, return it as part of the tuple, then simply use the tuple’s `sum` element as necessary in the rest of the code.

Composing a Tuple

To return a tuple containing multiple values from a function, you **compose** it by wrapping the values in parentheses, as in the return statement (line 22).

Accessing a Tuple’s Elements

When a tuple specifies names for its elements, you can access them by name using the dot (`.`) syntax. Line 34 assigns the tuple returned by `rollDice` to the variable `roll`, which is inferred to have the tuple type `(Int, Int, Int)`. The `switch` statement’s control expression (line 38) uses `roll.sum` to get the sum of the dice from the returned tuple.

Decomposing a Tuple

You can also **decompose** a tuple into individual variables or constants. For example, the statement

```
let (die1, die2, sum) = rollDice()
```

assigns the three values in the tuple to the constants `die1`, `die2` and `sum`, respectively. When decomposing a tuple, if you need only some of the values, you can ignore individual values with the underscore character (`_`), as in:

```
let (_, _, sum) = rollDice()
```

Explicit Casts Are Required for Numeric Conversions

Unlike many other programming languages, Swift does *not* allow implicit conversions between numeric types. To prevent a compilation error when you use a value of one numeric type where a different numeric type is expected, the compiler requires you to cast the value to the required type to force the conversion. This enables you to “take control” from the compiler. You essentially say, “I know this conversion might lose information, but for my purposes here, that’s fine.”

Function `rollDice` returns a tuple containing `Int` values; however, the random numbers returned by function `arc4random_uniform` are of type `UInt32`. To convert these to type `Int`, you must use an `Int` cast as shown in line 20:

```
let die1 = Int(1 + arc4random_uniform(6)) // first die roll
```

The cast `Int(1 + arc4random_uniform(6))` creates a *temporary* `Int` copy of the argument in parentheses.



Error-Prevention Tip 5.4

Each numeric type represents a different range of values. Disallowing implicit conversions—thus forcing you to use explicit casts for numeric conversions—prevents unintentional conversions between types. This is another Swift feature that eliminates errors.



Common Programming Error 5.2

Converting a numeric-type value to a value of another numeric type may change the value. For example, converting a `Double` value to an `Int` value may introduce truncation errors (loss of the fractional part) in the result.

5.6.3 Tuples as Function Arguments

After each call to `rollDice`, the program calls function `displayRoll` (lines 35 and 57) to display the two die values and the sum of the dice. The function (lines 26–28) receives one parameter (`roll`) which has the tuple type `(Int, Int, Int)`. In this case, we did not specify names for the elements in the tuple, so that we could show accessing a tuple’s members using indices and dot syntax, as in line 27. The first tuple element has index 0, so `roll.0` evaluates to the first die’s value, `roll.1` evaluates to the second die’s value and `roll.2` evaluates to their sum.

5.6.4 Accessing the Raw Value of an enum Constant

The `switch` statement at lines 38–51 performs its tasks based on the sum of the dice. Swift does not provide implicit conversions between `enum` constants and numeric types. However, each `enum` constant has a `rawValue` property that returns the constant’s raw value. Lines 40, 43 and 44 compare the `Int` sum of the dice to the raw `Int` values of several `DiceName` constants to determine whether the game was won or lost on the first roll. We use the raw `enum` constant values in this case because there are several sums (4, 5, 6, 8, 9 and 10) that don’t correspond to the `DiceName` `enum` constants.

Converting a Value to an enum Constant

You can use an `enum`’s initializer to get the `enum` constant that corresponds to a raw value. For example, using the `Months` `enum` discussed in Section 5.6.1, the expression

```
Months(rawValue: 2)
```

returns the `enum` constant `Months.February`. In a program that receives a month as a value in the range 1–12, you could use the `Months` `enum`’s initializer to convert those values to the corresponding `Months` `enum` constants for use in a `switch`’s cases. Because the argument could be invalid, the actual value returned by the initializer is a `Months?`—an optional value of type `Months`. We discuss this in more depth in Section 9.3.3.

5.7 Scope of Declarations

You've seen declarations of Swift entities, such as classes, methods, properties, variables and parameters. Declarations introduce names that can be used to refer to such Swift entities. The **scope** of a declaration is the portion of the code that can refer to the declared entity by its unqualified name. Such an entity is said to be “in scope” for that portion of the app. This section introduces several important scope issues. The basic scope rules are:

1. The scope of a parameter is the body of the method in which the declaration appears.
2. The scope of a local variable or constant is from the point at which it's defined to the closing right brace (}) of the block containing the definition.
3. The scope of a local variable that appears in the initialization section of a for statement's header is the body of that for statement and the other expressions in the header.
4. The scope of a local variable that receives each value in a for...in statement is the body of that for...in statement.
5. The scope of a method or property of a class is the entire body of the class.
6. A type, function, variable or constant defined outside any other language element has global scope from its point of definition to the end of the file in which the type, function, variable or constant is defined. Types and functions also have module scope—by default, they can be used from other files in the same module or in other apps that import that module, unless they're declared `private`.

Any block may contain variable declarations. If a local variable, constant or parameter in a method has the same name as a property of a class, the property is hidden until the block terminates. In Chapter 8, we discuss how to access hidden properties via the keyword `self`. The app in Fig. 5.6 demonstrates the scopes for a global variable, a property of a class and local variables in methods.

```

1 // fig05-06: Demonstrating scopes
2 var x = 5 // global variable x
3
4 class Scope {
5     var x = 1 // property hides global variable x in class Scope
6
7     // create and initialize local variable x during each call
8     func useLocalVariable()
9     {
10        var x = 25 // initialized each time useLocalVariable is called
11
12        println("\nlocal x on entering useLocalVariable is \(x)")
13        ++x // modifies this method's local variable x
14        println("local x before exiting useLocalVariable is \(x)")
15    }
16

```

Fig. 5.6 | Demonstrating scopes. (Part 1 of 2.)

```

17 // modify class Scope's property x during each call
18 func useProperty() {
19     println("\nproperty x on entering useProperty is \x")
20     x *= 10 // modifies class Scope's property x
21     println("property x before exiting useProperty is \x")
22 }
23 }
24
25 var scope = Scope() // create a Scope object
26
27 println("global variable x when program begins execution is \x")
28
29 scope.useLocalVariable()
30 scope.useProperty()
31 scope.useLocalVariable()
32 scope.useProperty()
33
34 println("\nglobal variable x before program terminates is \x")

```

```

global variable x when program begins execution is 5
local x on entering useLocalVariable is 25
local x before exiting useLocalVariable is 26

property x on entering useProperty is 1
property x before exiting useProperty is 10

local x on entering useLocalVariable is 25
local x before exiting useLocalVariable is 26

property x on entering useProperty is 10
property x before exiting useProperty is 100

global variable x before program terminates is 5

```

Fig. 5.6 | Demonstrating scopes. (Part 2 of 2.)

Line 2 defines and initializes the global variable `x` to 5. This variable is hidden in any block or method that declares local variable named `x` and in any class that defines a property named `x`. Class `Scope` (lines 4–23) defines a property `x` with the value 1 (line 5). We defined the class after the global variable `x` at line 2 to show that the class’s property `x` hides the global variable.

Line 25 defines an object of class `Scope` named `scope`. Line 27 outputs the value of global variable `x` (whose value is 5). Next, lines 29–32 call `Scope` methods `useLocalVariable` (lines 8–15) and `useProperty` (lines 18–22) that each take no arguments and do not return results. We call each method twice. Method `useLocalVariable` declares local variable `x` (line 10). When `useLocalVariable` is first called (line 29), it creates local variable `x` and initializes it to 25 (line 10), outputs the value of `x` (line 12), increments `x` (line 13) and outputs the value of `x` again (line 14). When `useLocalVariable` is called a second time (line 31), it re-creates local variable `x` and reinitializes it to 25, so the output of each `useLocalVariable` call is identical.

Method `useProperty` does not declare any local variables. Therefore, when it refers to `x`, class `Scope`’s property `x` (line 5) is used. When method `useProperty` is first called

(line 30), it outputs the value (1) or property `x` (line 19), multiplies the property `x` by 10 (line 20) and outputs the value (10) of property `x` again (line 21) before returning. The next time method `useProperty` is called (line 32), the property has its modified value, 10, so the method outputs 10, then 100. The app outputs the value of global variable `x` again (line 34) to show that none of the method calls modified the global variable `x`, because the methods all referred to variables or properties named `x` in other scopes.

5.8 Function and Method Overloading

You can define functions of the same name, as long as they have different sets of parameters (determined by the number, types and order of the parameters). This is called **function overloading** and can be used with a type's methods and initializers as well. When an overloaded function is called, the Swift compiler selects the appropriate function by examining the number, types and order of the arguments in the call. Function overloading is commonly used to create several functions with the *same name* that perform the same or similar tasks, but on *different types* or *different numbers of arguments*. For example, Swift function `max` is overloaded with two versions—one that returns the maximum of two values and one that returns the maximum of three or more values. Our next example demonstrates declaring and invoking overloaded functions. You'll see examples of overloaded initializers in Chapter 8, *Classes: A Deeper Look and Extensions*.

Declaring Overloaded Functions

In Fig. 5.7, we define overloaded versions of function `square`—one that calculates the square of an `Int` (and returns an `Int`) and one that calculates the square of a `Double` (and returns a `Double`). Although these functions have the same name and similar parameter lists and bodies, you can think of them simply as *different* methods. It may help to think of the functions names as “square of `Int`” and “square of `Double`,” respectively.

```

1 // fig05-07: Overloaded function definitions
2
3 // square function with Int argument
4 func square(value: Int) -> Int
5 {
6     println("Called square with Int argument: \(value)")
7     return value * value
8 }
9
10 // square function with Double argument
11 func square(value: Double) -> Double
12 {
13     println("Called square with Double argument: \(value)")
14     return value * value
15 }
16
17 // test overloaded square functions
18 println("Square of Int 7 is \(square(7))\n")
19 println("Square of Double 7.5 is \(square(7.5))")

```

Fig. 5.7 | Overloaded function definitions. (Part 1 of 2.)

```
Called square with Int argument: 7
Square of Int 7 is 49

Called square with Double argument: 7.5
Square of Double 7.5 is 56.25
```

Fig. 5.7 | Overloaded function definitions. (Part 2 of 2.)

Line 18 invokes method `square` with the argument `7`. Literal integer values are treated as type `Int`, so the method call in line 18 invokes the version of `square` at lines 4–8 that specifies an `Int` parameter. Similarly, line 19 invokes `square` with the argument `7.5`. Literal floating-point values are treated as type `Double`, so the method call in line 19 invokes the version of `square` at lines 11–15 that specifies a `Double` parameter. Each function first outputs a line of text to prove that the proper function was called in each case.

The overloaded functions in Fig. 5.7 perform the same calculation, but with two different types. Swift’s generics feature provides a mechanism for writing a single “generic function” that can perform the same tasks as an entire set of overloaded functions. We discuss generic functions in Chapter 11, Generics.

Distinguishing Between Overloaded Functions

The compiler distinguishes overloaded functions by their **signature**—a combination of the function’s name and the number, types and order of its parameters. The signature also includes the way those parameters are passed, which can be modified by the `inout` keyword (discussed in Section 5.11). If the compiler looked only at method names during compilation, the code in Fig. 5.7 would be *ambiguous*—the compiler would not know how to distinguish between the `square` functions. Internally, the compiler uses signatures to determine whether functions are unique, whether a class’s methods are unique and whether a class’s initializers are unique.

For example, in Fig. 5.7, the compiler will use the function signatures to distinguish between the “square of `Int`” function (the `square` function that specifies an `Int` parameter) and the “square of `Double`” function (the `square` function that specifies a `Double` parameter). If a function `someFunction`’s declaration begins as

```
func someFunction(a: Int, b: Double)
```

then that function will have a different signature than the function declared as

```
func someFunction(a: Double, b: Int)
```

The order of the parameter types is important—the compiler considers the preceding two functions to be distinct.

Return Types of Overloaded Functions

In discussing the logical names of functions used by the compiler, we did not mention the return types of the functions. This is because function calls cannot be distinguished by return type. Overloaded functions can have the *same* or *different* return types if the functions have *different* parameter lists. Also, overloaded functions need not have the same number of parameters.

5.9 External Parameter Names

By default, the parameter names you specify in a function definition are local to that function—they're used only in the body of that function to access the function's argument values. You can also define **external parameter names** that the caller is required to use when a function is called—as is the case for all the arguments to an initializer and any arguments after the first argument in a method call. This can help make the meaning of each argument clear to the programmer calling the function.

For each parameter, you can specify both an external name and a local name by placing the external name before the local name as in:

```
externalName localName: type
```

or you can specify that the local parameter name should also be used as the external parameter name by placing a # before the local parameter name, as we demonstrate in Fig. 5.8 (line 4). The function `power` (lines 4–12) calculates the value of its base argument raised to its exponent argument. The two calls to `power` (lines 15 and 16) each specify the parameter name before each argument. Once you expose an external parameter name, you must label the corresponding argument in a function call with a parameter name and a colon (:); otherwise, a compilation error occurs.

```
1 // fig05-08: External parameter names
2
3 // use iteration to calculate power of base raised to the exponent
4 func power(#base: Int, #exponent: Int) -> Int {
5     var result = 1;
6
7     for i in 1...exponent {
8         result *= base
9     }
10
11     return result
12 }
13
14 // call power with and without default parameter values
15 println("power(base: 10, exponent: 2) = \ (power(base: 10, exponent: 2))")
16 println("power(base: 2, exponent: 10) = \ (power(base:2, exponent: 10))")
```

```
power(base: 10, exponent: 2) = 100
power(base: 2, exponent: 10) = 1024
```

Fig. 5.8 | External parameter names.

Changing the Default External Parameter Names for an Initializer or Method

By default, the names of an initializer's parameters and the names of a method's parameters for every parameter after the first are used as their external names. You can customize a method's or initializer's external parameter names by specifying your own, using the same syntax we discussed for functions earlier in this section.

Why an External Name Is Not Required for a Method's First Argument

In Objective-C, method calls read like sentences. The method name refers to the first parameter, and each subsequent parameter has a name that's specified as part of the method call. In addition, method and parameter names often include prepositions to help make function calls read like sentences.

Apple wants Swift programmers to use similar naming conventions in their methods. Because the method name should refer to the first parameter, Swift provides only a local parameter name for the first method parameter, then provides local and external parameter names for all subsequent parameters. Using this naming convention, we could reimplement the power function as

```
func raiseBase(base: Int, #toExponent: Int) -> Int
```

In this case, we'd call the function as:

```
raiseBase(10, toExponent: 2)
```

which reads like the sentence, "Raise the base 10 to the exponent 2."

Requiring an External Parameter Name for a Method's First Argument

You can require a method's caller to provide an external parameter name for the method's first argument. To do so, simply precede the parameter name with # to use the local parameter name as the external parameter name or specify an external parameter name.

Passing Method Arguments Without Parameter Names

You can allow a method to be called without labeling its arguments by using an underscore (_) as each parameter's external name.

5.10 Default Parameter Values

Methods can have **default parameters** that allow the caller to vary the number of arguments to pass. A default parameter specifies a **default value** that's assigned to the parameter if the corresponding argument is omitted.

You can create functions with one or more default parameters. *All default parameters must be placed to the right of the function's nonoptional parameters*—that is, at the end of the parameter list. Each default parameter must specify a default value by using an equal (=) sign followed by the value.

When a parameter has a default value, the caller can optionally pass that particular argument. For example, the function

```
func power(base: Int, exponent: Int = 2) -> Int
```

specifies a default second parameter. Any call to `power` must pass at least an argument for the parameter `base`, or a compilation error occurs. Optionally, a second argument (for the `exponent` parameter) can be passed to `power`. Consider the following calls to `power`:

```
power() // compilation error--first argument is required
power(10) // calls power with 2 as the second argument
power(10, exponent: 3) // explicitly specifying both arguments
```

The first call generates a compilation error because this function requires a minimum of one argument. The second call is valid because the one required argument (10) is being

passed explicitly—the optional exponent is not specified in the method call, so 2 is passed by default. The last call is also valid—10 is passed as the required argument and 3 is passed as the optional argument. A function’s default parameter names are automatically external parameter names—when you provide an argument for a default parameter, you *must* specify the default parameter’s name with that argument in the function call.

Figure 5.9 demonstrates a default parameter. The program reimplements the power function of Fig. 5.8 without external parameter names and with a default value for its second parameter. Lines 15–16 call function power. Line 15 calls it without the second argument. In this case, the compiler provides the second argument, 2, using the default value specified in line 4, which is not visible to you in the call. Notice that the call to power at line 16 requires the parameter name for the second argument.

```

1 // fig05-09: Default parameter values
2
3 // use iteration to calculate power of base raised to the exponent
4 func power(base: Int, exponent: Int = 2) -> Int {
5     var result = 1;
6
7     for i in 1...exponent {
8         result *= base
9     }
10
11     return result
12 }
13
14 // call power with and without default parameter values
15 println("power(10) = \(power(10))")
16 println("power(2, exponent: 10) = \(power(2, exponent: 10))")

```

```

power(10) = 100
power(2, exponent: 10) = 1024

```

Fig. 5.9 | Default parameter values.

5.11 Passing Arguments by Value or by Reference

Swift allows you to pass arguments to functions by value or by reference. When an argument is passed by *value* (the default for value types in Swift), a *copy* of its value is made and passed to the called function. Changes to the copy do *not* affect the original variable’s value in the caller. This prevents the accidental side effects that so greatly hinder the development of correct and reliable software systems. Each argument that’s been passed in the programs in this chapter so far has been passed by value. When an argument is passed by *reference*, the caller gives the function the ability to access and modify the caller’s original variable.

To pass an object of a class type by reference into a function, simply provide as an argument in the function call the variable that refers to the object. Then, in the function body, reference the object using the parameter name. The parameter refers to the original object in memory, so the called function can access the original object directly.

We've considered value types and reference types. A major difference between them is that value-type variables store *values*, so specifying a value-type variable in a function call passes a *copy* of that value to the method. Reference-type variables store *references to objects*, so specifying a reference-type variable as an argument passes the function a *copy of the reference* that refers to the object. Even though the reference itself is passed by value, the function can still use the reference it receives to interact with—and possibly modify—the original object. Similarly, when returning information from a function via a return statement, the function returns a *copy* of the value stored in a value-type variable or a copy of the reference stored in a reference-type variable. When a reference is returned, the caller can use that reference to interact with the returned reference-type object.

inout Parameters

What if you would like to pass a variable by reference so the called function can modify the variable's value in the *caller*? To do this, Swift provides keyword **inout**. Applying **inout** to a parameter declaration allows you to pass a variable to a function *by reference*—the called function will be able to modify the original variable in the caller. It's a compilation error to pass a constant to an **inout** parameter. A function can use multiple **inout** parameters as another way to “return” multiple values to a caller. You can also pass a reference-type variable by reference, which allows you to modify it so that it refers to a *new* object.

Demonstrating an inout Parameter

The app in Fig. 5.10 uses the **inout** keyword to allow a function to modify its `Int` argument. Function `square` (lines 4–6) multiplies its parameter `value` by itself and assigns the result to `value`. The `Int` parameter is preceded with **inout**, which indicates that the argument passed to this method must be an `Int` and that it will be passed by reference. Because the argument is passed by reference, the assignment at line 5 modifies the original argument's value in the caller.

```

1 // fig05-10: Pass-by-reference with inout parameters
2
3 // square function that modifies its argument in the caller
4 func square(inout value: Int) {
5     value *= value // squares value of caller's variable
6 }
7
8 // test inout parameter
9 var x = 5
10 println("Original value of x is \(x)")
11 square(&x)
12 println("Value of x after calling square(&x) is \(x)")

```

```

Original value of x is 5
Value of x after calling square(&x) is 25

```

Fig. 5.10 | Pass-by-reference with **inout** parameters.

Passing an Argument by Reference

Line 9 initializes variable `x` to 5. Line 10 displays `x`'s original value. When you pass a variable to a method with a reference parameter, you must precede the argument with an `&` (line 11)—similar to a pointer in languages like Objective-C, C and C++. After line 11 squares `x`'s value, line 12 displays the new value. Notice that `x` is now 25.



Software Engineering Observation 5.2

By default, value types are passed by value. Objects of reference types are not passed to methods; rather, references to objects are passed to methods. The references themselves are passed by value. When a method receives a reference to an object, the method can manipulate the object directly, but the reference value cannot be changed to refer to a new object.

5.12 Recursion

Swift supports recursion. A **recursive function** calls itself, either *directly* or *indirectly* through another function.

Recursive Factorial Calculations

Figure 5.11 uses recursion to calculate and display the factorials of the integers from 0 to 10. The recursive function `factorial` (lines 4–11) first tests to determine whether a terminating condition (line 6) is true. If `number` is less than or equal to 1 (the base case), `factorial` returns 1, no further recursion is necessary and the function returns. If `number` is greater than 1, line 9 expresses the problem as the product of `number` and a recursive call to `factorial` evaluating the factorial of `number - 1`, which is a slightly simpler problem than the original calculation, `factorial(number)`.

```

1 // fig05-12: Recursive factorial function
2
3 // recursive factorial function
4 func factorial(number: Int64) -> Int64 {
5     // base case
6     if number <= 1 {
7         return 1
8     } else { // recursion step
9         return number * factorial(number - 1)
10    }
11 }
12
13 // calculate the factorials of 0 through 10
14 for counter in 0...10 {
15     println("\(counter)! = \(factorial(Int64(counter)))")
16 }

```

```

0! = 1
1! = 1
2! = 2

```

Fig. 5.11 | Recursive `factorial` function. (Part I of 2.)

```

3! = 6
4! = 24
5! = 120
6! = 720
7! = 5040
8! = 40320
9! = 362880
10! = 3628800

```

Fig. 5.11 | Recursive factorial function. (Part 2 of 2.)

Function `factorial` receives a parameter of type `Int64` and returns a result of type `Int64`. As you can see in Fig. 5.11, factorial values become large quickly. We chose `Int64` (which can represent relatively large integers) so that the app could calculate factorials up to `20!`. Unfortunately, the function produces large values so quickly that `21!` exceeds the maximum value that can be stored in an `Int64` variable, causing an overflow. Due to the restrictions on the integral types, variables of type `Float` or `Double` might ultimately be needed to calculate factorials of larger numbers.

A strength of object-oriented programming languages like Swift is that they can be extended with new types to meet your applications' needs. For example, you could create a type (e.g., `HugeInt`) that supports arbitrarily large integers for use in large-number factorial calculations.



Common Programming Error 5.3

Either omitting the base case or writing the recursion step incorrectly so that it does not converge on the base case will cause infinite recursion, eventually exhausting memory. This error is analogous to the problem of an infinite loop in an iterative (nonrecursive) solution.

5.13 Nested Functions

You can nest function definitions in other function definitions. This can be useful for organizing complex functions. Rather than defining at global scope a utility (helper) function that's called by only one other function, you can nest the utility function's definition in the scope of the function that uses it. This hides it from the rest of your code. For example, an array-sorting function could define a nested `swap` function for swapping elements into sorted order.

If necessary, an enclosing function can return a nested function so that it can be called from other scopes—for example, you could define a function that returns a nested function based on a value passed to the enclosing function (as we do in this section's example). A nested function also has access to the local variables and constants in its enclosing function's scope, including the enclosing function's parameters.

Figure 5.12 contains a mechanical nested-functions example. Function `sortOrder` (lines 4–16), based on the `Bool` parameter `increasingOrder`'s value, returns either the nested function `ascending` (defined at lines 6–8) or the nested function `descending` (defined at lines 11–13). To make the purpose of `sortOrder`'s argument clear, we specified that its parameter name (`increasingOrder`) should also be its external parameter name—thus, each call to `sortOrder` (lines 19 and 28) labels its argument with `increasingOrder`.

```

1 // fig05-12: Mechanical example of nested functions
2
3 // return a function that determines the ordering of two Ints
4 func sortOrder(#increasingOrder: Bool) -> (Int, Int) -> Bool {
5     // return true if x and y are in ascending order
6     func ascending(x: Int, y: Int) -> Bool {
7         return x < y
8     }
9
10    // return true if x and y are in descending order
11    func descending(x: Int, y: Int) -> Bool {
12        return x > y
13    }
14
15    return (increasingOrder ? ascending : descending)
16 }
17
18 // get function for comparing Ints to see if they're in ascending order
19 var order = sortOrder(increasingOrder: true)
20
21 if order(7, 5) {
22     println("7 and 5 are in ascending order")
23 } else {
24     println("7 and 5 are not in ascending order")
25 }
26
27 // get function for comparing Ints to see if they're in descending order
28 order = sortOrder(increasingOrder: false)
29
30 if order(7, 5) {
31     println("7 and 5 are in descending order")
32 } else {
33     println("7 and 5 are not in descending order")
34 }

```

```

7 and 5 are not in ascending order
7 and 5 are in descending order

```

Fig. 5.12 | Mechanical example of nested functions.

Every Function Has a Type and Can Be Treated as Data

Each function you define has a type that's determined by the types of its parameters and by its return type. The return type of function `sortOrder` is specified as

```
(Int, Int) -> Bool
```

A function type consists of parentheses containing the parameter types, followed by `->` and the return type. The preceding type indicates that the value returned by `sortOrder` is a function type for a function that receives two `Int` parameters and returns a `Bool`. Functions `ascending` and `descending` meet these requirements.

Because every function has a type, you can assign functions to variables, pass them to functions and methods, and return them from functions and methods. We'll discuss functions as data in more detail in Section 6.7.

Assigning a Function to a Variable and Using the Variable to Call the Function

Line 19 calls function `sortOrder` with the argument `true` to indicate that `sortOrder` should return the function that determines whether two `Ints` are in ascending order. The returned function is assigned to the variable `order`, which is inferred to have the type

```
(Int, Int) -> Bool
```

Once you've assigned a function to a variable, you can use the variable to call the function, as shown in line 21. Line 28 calls `sortOrder` with the argument `false` to get the function that determines whether two `Ints` are in descending order, then line 30 calls that function.

5.14 Wrap-Up

In this chapter, we continued our discussion of functions and methods. We discussed that Swift automatically creates modules for packaging reusable software components. We introduced Darwin—Apple's UNIX-based core of OS X and iOS—and imported the Darwin module so we could use the random-number generator.

We used `enum` types to create sets of named constants with and without values for the constants. You returned multiple values from a function via a tuple, passed a tuple to a function and accessed a tuple's elements via both names and indices.

We discussed the scope of identifiers. We used overloading to define multiple functions with the same name that performed similar tasks but with different types and/or different numbers of parameters.

We discussed differences in how functions and methods are called, and we presented the concepts of local parameter names vs. external parameter names. You saw that, when external parameter names are provided in a function definition, they must be used in the function call to label the corresponding arguments. You used `#` to expose a local parameter name as the external parameter name. We also showed how to disable this feature in methods—by placing an underscore (`_`) before the parameter's name—so that parameter names are not required in a method call.

You specified a default parameter value and saw that the compiler supplied that value in a function call when you did not explicitly provide an argument for that parameter.

We discussed how value-type and reference-type arguments are passed to methods and demonstrated how to pass arguments by reference by declaring the parameter as `inout` and providing an ampersand (`&`) before the corresponding argument in a function call. We demonstrated that Swift supports recursive functions and nested functions.

In Chapter 6, you'll use `Arrays` to maintain lists and tables of data. You'll also create functions with variable-length argument lists. We'll continue our discussion of functions in Chapter 6 which also presents closures—anonymous functions that are typically defined in the scope of a function or method and commonly passed as arguments to other functions or methods. As you'll see, a function is a closure with a name. Swift's `Array` type provides methods `filter`, `map` and `reduce` that receive closures as arguments—which enable you to express complex operations in a more concise and elegant manner than with full function definitions. We'll present additional method and initializer concepts in Chapters 8–10.



Index

Symbols

`_`, underscore for ignoring a tuple value during decomposition 82

`--`, predecrement/postdecrement operators **53**

`-`, subtraction operator 28, 29

`:` notation for inheritance 221

`!`, logical NOT operator **68**
truth table 68

`!=`, not equals operator 30

`!==`, not identical to operator 30, **45**

`?:`, ternary conditional operator **52**

`..`, dot syntax **36, 41**

`...`, closed range operator **56, 59, 107**

`..<`, half-open range operator **56, 59, 103, 107, 108**

`{`, left brace 35

`}`, right brace 35

`*`, multiplication operator 28, 29

`*=`, multiplication assignment operator 53

`/`, division operator 28, 29

`/*...*/`, multiline comment **22**

`//`, end-of-line comment **22**

`/=`, division assignment operator 53

`\`, backslash special character 24

`\'`, single-quote special character 24

`\"`, double-quote special character 24

`\0`, null special character 24

`\n`, line feed special character 24

`\r`, carriage-return special character 24

`\t`, tab special character 24

`&-`, overflow subtraction operator 29

`&*`, overflow multiplication operator 29

`&/`, overflow division operator 29

`&&`, logical AND operator **66, 67**
truth table 67

`&%`, overflow remainder operator 29

`&+`, overflow addition operator 29

`%`, remainder operator 28, 29

`%@` format specifier **61, 62**

`%=`, remainder assignment operator 53

`+` for concatenating Arrays **101**

`-` (minus sign) formatting flag **62**

`+`, addition operator 28, 29

`++`, preincrement/postincrement operators **53**

`+=` operator for Arrays **104, 106, 107**

`+=`, addition assignment operator **52**

`<`, less than operator 30

`<=`, less than or equal operator 30

`-=`, subtraction assignment operator 53

`==`, is equal to operator 30

`===` identical to operator 30, **45**

`>`, greater than operator 30

`>=`, greater than or equal to operator 30

`||`, logical OR operator 66, **67**
truth table 67

Numerics

0, format flag 163

A

abbreviating assignment expressions 52

`abs` C function 74

abstract class 228, 230, 231

abstract method 230

abstract property 230

access modifier **35**
 `internal` **35, 37, 46, 226**
 `private` **35, 46, 226**
 `public` **35, 37, 46, 226**

access modifiers
 `public` 160

Accessibility 291, 311
 accessibility strings 289
 Accessibility Inspector 312
 UIAccessibility protocol **312**

- action 50, **324**
 - create 340
- action (event handler) 340
- actual types in generics 254
- adaptive design **11**
- Add Missing Constraints** 334
- addition 28, 29
- addition compound
 - assignment operator, += **52**
- adopt a protocol **238**, 241
- advance global function **270**
- Alignment** attribute of a **Label** 332
- anonymous function 4, 108
- AnyObject type **279**, 345
- API 7
- app icons 298
- app name **293**
- App Store xxxii
- app templates 292
 - Game** **292**
 - Master-Detail Application** **292**
 - Page-Based Application** **292**
 - Single View Application** **292**
 - Tabbed Application** **292**
- append method of a **String** **270**
- append method of **Array** **104**, 106
- AppKit 7
- Apple Inc. 3
- Apple Macintosh 3
- Apple TV 3
- Apple World Wide
 - Developer Conference (WWDC) xix, 3
- arc4random UNIX function **76**
- arc4random_uniform
 - UNIX function **76**, 77
 - upper bound 77
- arithmetic compound
 - assignment operators **52**
- arithmetic operators 28
 - , subtraction 28, 29
 - *, multiplication 28, 29
 - /, division 28, 29
 - &-, overflow subtraction 29
 - &*, overflow multiplication 29
 - &/, overflow division 29
 - &%, overflow remainder 29
 - &+, overflow addition 29
 - %, remainder 28, 29
 - +, addition 28, 29
- Array**
 - count property **98**
- array bounds checking 5
- Array literal** **100**, 101
 - for multidimensional **Array** 125
 - nested **125**
- Array of one-dimensional Arrays** 125
- Array Swift Standard Library** type 72, **97**, 153, 278, 325
 - + operator for concatenating **Arrays** **101**
 - += operator **104**, **106**, 107
 - append method **104**, 106
 - delete a subset of the elements 108
 - description property **99**, 100
 - element type 99
 - filter method **113**
 - initializer with no parameters 100
 - initializer with two parameters 100
 - insert method **104**, 107
 - isEmpty property **105**
- Array Swift Standard Library** type (cont.)
 - last property **261**
 - map method **113**, 115
 - pass by reference 123
 - reduce method **114**, 115, 128, 142
 - removeAll method **104**, 107
 - removeAtIndex method **104**, 107
 - removeLast method **104**, 107
 - replace a subset 108
 - reverse method **112**
 - select a subset 108
 - sort method **109**
 - sorted method **109**, 111
 - two-dimensional 124
 - zero-based counting 98
- as cast operator 278, 279
- as operator **238**
- as? operator **237**
- aspect ratio 303
- assert function **282**
- asset catalog **291**, 298
- assignment operators **52**
- Assistant** editor (Xcode) 12, **16**, **295**, 338, 340
- associated type for a protocol 263
- associated value for an enum constant **210**
- associative array 132
- associativity
 - default value none 284
 - left **284**
 - none **284**
 - of a new operator 284
 - right **284**
- associativity context-sensitive keyword **285**
- associativity of operators **29**, 32
 - left to right 29
 - right to left 29

- Attributes inspector** **303**
 - auto layout 11, **290**, 301, 306, 334
 - auto layout constraints
 - adding 334
 - Equal Widths** 335
 - missing 334
 - automatic reference counting (ARC) 159, **184**, 193, 343
 - Autoshrink** 305, 332
- B**
- Background** attribute of a GUI component 328
 - backslash (\) **24**
 - base class 248, 342
 - topmost superclass in a class hierarchy **220**, 248
 - base internationalization **314**
 - base language (internationalization) **314**, 315
 - `becomeFirstResponder`
 - method of a GUI component **325**, 344
 - binary operator 28
 - body
 - of a class definition 35
 - of an `if` statement 29
 - `Bool` expression **52**
 - `Bool` primitive type **52**
 - `Bool` type **26**, 27
 - Boolean and numeric Swift Standard Library types 72
 - braces { and }
 - not required 56
 - branch statement 29
 - break statement 57, **64**
 - Breakpoint** navigator **16**, **294**
 - bridging between Objective-C and Swift **153**, 279, 325, 348
 - Apple's *Using Swift with Cocoa and Objective-C* guide 153, 279
 - downcast 279
 - bullseye symbol for an outlet or action 339
 - bundle identifier (bundle ID) 15, 293
- C**
- C Standard Library 73
 - camel case naming **27**
 - card face 204
 - card games 116
 - carriage return 24
 - case in an enum 80
 - case keyword **56**
 - case sensitive 27
 - cast 82
 - categories in Objective-C 159, 174
 - `ceil` C function 74
 - chain of initializer calls 248
 - class 72
 - camel case naming 35
 - constructor 37
 - default constructor **38**
 - definition **35**, 342
 - hierarchy **218**
 - name 35
 - class keyword
 - for a type property or type method in a class 190
 - for defining a class **35**
 - class method in other object-oriented languages 187
 - class variable 187
 - classes
 - Dictionary** **132**
 - `NSArray` 153, 279, 325
 - `NSDate` **181**, 182, **182**
 - `NSDateFormatter` **182**, 184
 - `NSDecimalNumber` 34, 63, **185**, 274, 323
 - `NSDictionary` 153, 279, 325
 - `NSMutableArray` 153, 279, 325
 - classes (cont.)
 - `NSMutableDictionary` 153, 279, 325
 - `NSMutableString` 279
 - `NSNumber` 347, 348
 - `NSNumberFormatter` **41**, 323, 347
 - `NSString` 153, 279, 325
 - `UIImageView` **290**, 302
 - `UILabel` **290**, 324
 - `UISlider` **324**
 - `UITextField` **324**
 - `UIViewController` **324**, 344
 - class-only protocol **246**
 - optional capabilities **246**
 - class-only protocols 246
 - client code 37
 - closed range operator (...) 56, 107
 - closure 4, 142
 - anonymous function **108**
 - closure expression **109**
 - empty parameter list 111
 - fully typed 111
 - inferred types 111
 - inferred types and implicit return 112
 - operator function 112
 - shorthand argument names 112
 - Cocoa **7**
 - Cocoa Touch **7**, 290, 301, **322**, 323
 - code-completion suggestions 22
 - code reuse 215
 - Code Snippet** library **301**
 - collision in a hashtable **154**
 - color opacity 328
 - column 124
 - columns of a two-dimensional Array 124
 - comment
 - multiline, `/*...*/` **22**
 - single-line, `//` **22**

- company identifier **293**, 326
 - Comparable protocol 247, 259
 - String 268
 - Comparable Swift Standard Library protocol 72
 - comparative operators **30**, 247, 259
 - compile-time type safety 254
 - componentsSeparatedByString method of class NSString **152**
 - compose a tuple 82
 - composition **181**
 - compound assignment operators **52**
 - compound interest 60
 - computed property **37**, 117, 160, 163, 174, 230
 - get accessor **117**, 178, 179
 - read-only 163, 178
 - set accessor **117**, 178, 179
 - shorthand read-only 163
 - struct 198
 - computed type property 187, 189
 - struct 198
 - concatenate Strings 22, 52
 - concrete class in other object-oriented programming languages 230
 - condition **29**
 - conditional statement 49, **49**
 - if...else **50**
 - Conditional Statements
 - if **29**
 - conform to a protocol **238**
 - connect a GUI control to a corresponding 324
 - Connection type 339
 - Connections inspector **303**
 - constant property 36, 324
 - constant value-type object 196
 - constructor in other object-oriented programming languages 248
 - context-sensitive help 16, 41, **295**
 - context-sensitive keyword 285
 - context-sensitive keywords 32
 - continue statement **65**, 355
 - control expression **55**
 - control statement
 - nesting **50**
 - stacking **50**
 - control variable 63
 - convenience initializer **167**, 168, 172, 174
 - protocol conformance 241
 - convenience initializer 249, 251
 - convenience keyword **168**
 - copy constructor 169
 - copy method of class NSObject **278**, 279
 - copy-on-write **201**
 - cos C function 74
 - count property of type Array **98**, 104
 - count property of type Dictionary 141
 - countElements global function 61, 119
 - counter-controlled loop 63
 - craps (casino game) 77
 - create an action in Interface Builder 340
 - create an outlet in Interface Builder 338
 - creating and initializing an Array 101
 - currency format 338
 - currency formatting 322
 - CurrencyStyle constant from the NSNumberFormatterStyle enumeration 186, 219
 - CurrencyStyle constant of the NSNumberFormatterStyle enumeration 348
 - custom name for the constant in a property observer 162
- ## D
- dangling-else problem **52**
 - Darwin module **73**, 76
 - dateFormat property of class NSDateFormatter **184**
 - dateStyle property of class NSDateFormatter **182**
 - dealing a deck of cards 116
 - deallocate an object 185
 - Debug area (Xcode) 16, 17, 293, 295
 - Debug navigator **16**, **294**
 - debugger 12
 - decimal separator 219
 - decimalNumberByAdding method of class NSDecimalNumber **187**, 276, 349
 - decimalNumberByDividingBy method of class NSDecimalNumber 349
 - decimalNumberByMultiplyingBy method of class NSDecimalNumber **187**, 220, 275, 349
 - declaration
 - import **41**, 342
 - declaration modifier **285**
 - decompose a tuple **82**, 142
 - ignore a value with `_` 82
 - decrement operator, `--` **53**
 - default case in a switch **56**
 - default initializer **38**, 160, 162, 198, 249
 - struct 199
 - default parameter **89**
 - default value **89**

deinit keyword **185**
 inheritance 251
deinitializer **185**, 189, 251
 not allowed in value types 198
delegate protocol 246
delete a subset of an Array 108
dependent condition 68
Deployment Info 297
derived class 342
description property
 Array **99**, 100
 Dictionary 134, 136
designated initializer **167**, 172, 222, 223, 248, 249, 250
 protocol conformance 241
designated initializer in a base class 248
Device Orientation 297
Devices project setting 293
Devices window (Xcode 6) 22
dice game 77
Dictionary Swift Standard Library type **132**, 136, 153, 278, 325
 Arrays as values 142
 count property 141
 description property 134, 136
 empty Dictionary 136
 empty literal, [:] **135**, 141
 equality operators 140
 generic type 133
 immutable 134
 inserting new key–value pairs 145, 147
 isEmpty property 141
 key 132
 keys property 143
 literal **135**

Dictionary Swift Standard Library type (cont.)
 modifying the value associated with a key 145, 147
 mutable 134
 removeAll method **151**
 removeValueForKey method **151**
 removing key–value pairs 145, 147
 shorthand notation 133
 subscripting operations 145
 type inference 136
 updateValue method **150**, 151
 value 132
 values property 145
Dictionary Swift Standard Library type 72
didSet property observer **162**
direct superclass **218**
disabilities 291, 311
display a line of text 22
division 28, 29
division compound
 assignment operator, /= 53
do...while loop statement 50, **58**
document outline window **307**
dot (.) syntax **36**, **41**
double-precision floating-point number **34**
double quotes, " 22, 24
Double type **26**, **27**, **34**, **34**
downcast **237**, 238, 279
duplicate existing GUI components 324
dynamic binding **237**
dynamically typed **345**

E
Editing Changed event for a Text Field 340, 345
Editor area (Xcode) 16, 293, 294
element of chance 76
element type of an Array 99
ellipsis (...) in a method parameter list **128**
else keyword 51
emojis in Swift code **26**
empty Dictionary literal [:] **135**, 141
empty Dictionary object 136
empty statement (in C-based languages) 31
empty String 347
encapsulation 46
endIndex property of a String **270**
enum **80**, 80
 case 80
 constants in switch statement cases 205
 failable initializer 209
 initializer 209
 keyword 195
 raw type **81**
 unique raw values for constants 202
enum constant **80**
 associated values **210**
 raw value **81**
 rawValue 204
 rawValue property **83**
enum constants in cases 205
enum keyword 202
enum type **80**
enumerate function **103**
enumeration 195
Equal Widths constraint 335
equality operators 140
Equatable protocol 247
 String 268

Equatable Swift Standard
 Library protocol 73
 Error-Prevention Tips
 overview xxi
 escape character **24**
 event handler 340
 event-handling method 324
 Events
 Editing Changed event for
 a **Text Field** 340, 345
 Value Changed event for a
 Slider 340, 345
 exception handling 163
 exclamation point (!) to
 unwrap an optional 145
 exhausting memory 93
 exit point
 of a control statement 50
 exiting a **for** statement 65
 exp C function 74
 explicit cast 82
 exponentiation operator 285
 expression **28**
 extended graphene cluster
 268
 extensible **227**
 extension 199
 computed property 174
 convenience initializer
 174
 keyword 159, **174**
 method 174
 extension for conforming
 to a protocol 238, 239,
 242
 external iteration **113**
 external parameter name
 # to use local parameter
 name **88**
 for a function parameter
 88

F

face of a card 204
 factorial 92
 failable 172

failable initializer 159, **170**,
173, 220, 223, 230, 231
 convenience initializer
 172
 designated initializer 172
 init? 172
 failable initializer for an enum
 209
 failable initializer in a
 protocol 241
 false keyword **29**, 52
 fatalError function 231
 field width **62**
 file in the **Project** navigator
 18, 296
File inspector **16**, **295**
File Template library **301**
 filter elements of an **Array**
 114
 filter method of **Array**
 113
 final
 class **248**
 method **248**
 property **248**
 subscript **248**
Find navigator **16**, 294
Finder window **321**
 first responder **325**
 Fisher-Yates shuffle
 algorithm 119
 fixed text
 in a format string **61**
 Fix-it 12
 Float type **26**, **27**, 34, **34**
 floating-point literal
 Double by default 34
 floating-point number **34**
 double precision **34**
 Double type **34**
 Float type **34**
 single precision **34**
 floor C function 74
 for loop statement 50, **63**
 for...in loop 50, **58**
 nested 126, 128

force unwrap an optional
 with ! 145, 148
 format specifiers **61**
 %@ **61**, **62**
 format string **61**
 formatted output
 - (minus sign) formatting
 flag **62**
 0 flag 163
 field width **62**
 left justify **62**
 minus sign (-) formatting
 flag **62**
 formatted text
 right align **62**
 Foundation framework 7,
 41, 322, 323, 348
 NSNumberFormatter
 class **41**
 frameworks **40**
 Foundation 41, 323
 UIKit **301**, 323, 324, 342
 free (global) function **22**
 free function 40, 72
 fully typed closure expression
 111
 func keyword **40**
 function 40
 definition 75
 external parameter name
 88
 generic declaration **140**
 multiple return values 82
 overloading **86**
 functions
 advance **270**
 assert **282**
 countElements 61, 119
 enumerate **103**
 fatalError 231
 max **76**
 precondition **281**
 print **23**, 23, 73
 println **22**, 23, 73
 sort 73
 sorted 73

functions (cont.)
 stride **59**, 60, **103**
 with multiple return
 values 5

G

game playing 76
Game template **292**
 generic function 254
 maximum 258
 generic function declaration
140
 generic overloaded operator
 function 286
 generic parameter clause **256**
 generic type **99**, 133, 254
 generic type constraint 134
 generics 5
 actual types 254
 associated type for a
 protocol 263
 function overload 259
 generic parameter clause
256
 method 256
 placeholder for a type 254
 specialization **257**
 type 259
 type argument **257**
 type constraint **259**
 type parameter **140**, 256
 where clause **259**
 get accessor of a computed
 property **117**, 178, 179
 getter for a property 36
 Git 293
 global (free) function **22**
 global function 40, 72
 global variable
 private 189
 Grand Central Dispatch
 (GCD) 113
 Graphical User Interface
 (GUI) **3**
 group in the **Project**
 navigator 18, 296

grouping related software
 components (module) **46**,
73
 guard condition in a case 57
 GUI Components
Image View **290**
Label **290**, 327, 328
 naming convention 337
Slider 320
 guide lines 302

H

half-open range operator
 (. . <) **56**, 59, 103, 107,
 108
has-a relationship **181**
 hash table 154
 Hashable protocol **134**,
 217, 248, 259
 hashing **154**
 hash-table collisions 155
 hasPrefix method of a
String **270**
 hasSuffix method of a
String **270**
 height or a GUI component
 329
 “hidden” fields 84
 HIG (Human Interface
 Guidelines) 302
 horizontal tab 24
 Human Interface Guidelines
 (HIG) 302, 327

I

@IBAction 345
 @IBAction event-handling
 method **324**
 @IBOutlet property **324**,
 343
 iCloud 7
 IDE (integrated
 development
 environment) 10
 identical to (===) operator
 30, **45**
 identifier **26**
 identifier naming 26
 identifiers
 camel case naming 35
Identity inspector **303**
 identity operators 140
 identity value in a reduction
 operation 115
 if conditional statement **29**
 if...else conditional
 statement **50**
Image attribute 303
 image set **291**, 298
Image View **290**, 302, 303
 Images.xcassets 298
 immutable 99, **113**
 by default 195
 Dictionary 134
 implementation of a
 function 230
 implicitly unwrapped
 failable initializer **173**
 implicitly unwrapped
 optional 220, 222, 343
 import declaration **41**, 342
 #import preprocessor
 directive **323**
 in keyword
 introduce a closure’s body
111
 increment
 expression 65
 operator, ++ 53
 increment and decrement
 operators 53
 indentation 51
 index (subscript) 98
 indirect superclass **218**
 infer enum constant’s type in
 a switch 205
 infinite loop 64, 93
 infinite recursion 93
 inheritance **215**, 221, **344**
 : notation 221
 base class (topmost
 superclass) **220**, 248

- inheritance (cont.)
 - deinitializers 251
 - examples 217
 - hierarchy **218**
 - hierarchy for university
 - CommunityMembers 218
 - initialization 248
 - initializers 249
 - two-phase initialization process **249**, 249, 250
 - inherits 342
 - init keyword **38**
 - init! failable initializer **173**
 - init? failable initializer 172
 - initialization
 - two-phase initialization process in class hierarchies **249**, 249, 250
 - initializer 37, 38, 42, 136, **173**
 - call another initializer of the same class using self 168
 - convenience **167**, 168
 - delegation 168
 - designated **167**, 249
 - enum 209
 - failable 159, **170**
 - failable convenience initializer 172
 - failable designated initializer 172
 - inherit 249
 - init! **173**
 - init? 172
 - no-argument 168
 - overloaded **166**
 - override a designated initializer 250
 - struct 198, 199
 - initializers cannot specify a return type 40
 - initializing two-dimensional Arrays in declarations 126
 - inout keyword **91**, 195, 262
 - in an overloaded assignment operator function 272
 - inout parameter
 - passing an Array by reference 123
 - insert method of a String **270**
 - insert method of Array **104**, 107
 - inspector 16, 295, 302
 - Attributes **303**
 - Connections **303**
 - File **16**, **295**
 - Identity **303**
 - Quick Help **16**, 41, 295
 - Size **303**
 - instance method 188, 240
 - instance property 188, 240
 - Instruments 12
 - Int cast 83
 - Int primitive type 53
 - Int type **25**, **27**
 - Int16 type **25**
 - Int32 type **25**
 - Int64 type **25**
 - Int8 type **25**
 - integer **27**
 - quotient 28
 - value 27
 - integer division **28**
 - integrated development environment (IDE) 10
 - Interface Builder **3**, 11, 12, **12**, 289, 290, **290**
 - duplicate existing GUI components 324
 - Pin tools 335
 - interface in other object-oriented programming languages 238
 - internal
 - access modifier **35**, 37, 46, 226
 - internal iteration **113**
 - internationalization **291**, 308, **313**
 - base language **314**, 315
 - lock your components for localization 314
 - Internationalization and Localization Guide* 314
 - iOS 8 **3**
 - iOS 8 for Programmers: An App-Driven Approach with Swift* 7
 - iOS app templates 292
 - iOS Developer Enterprise Program **xxxii**
 - iOS Developer Library Reference* 7, 323
 - iOS Developer Program **xxxii**, 308
 - iOS Developer University Program **xxxii**
 - iOS simulator 289, **291**, 308
 - iPad 3
 - iPhone 3
 - iPod Touch 3
 - is-a relationship **217**
 - is operator **346**
 - isEmpty property
 - Array **105**
 - Dictionary 141
 - String 269, **347**
 - Issue navigator **16**, 294
 - iteration of a loop 65
 - iteration statements **50**
- ## J
- Jobs, Steve 3
 - join method of a String **271**
 - jump bar in the Assistant editor 338
 - Jump To Definition 41
- ## K
- key in a Dictionary 132
 - keyboard
 - how to display 325, 344

keyboard shortcuts 18, 296
Keyboard Type attribute of a
 Text Field 334
 keys property of type
 Dictionary 143
 key-value pair 5, 132, **135**,
 155
 keywords 50
 @objc 238
 as **238**
 as? **237**
 associativity **285**
 Bool **52**
 break **57**
 case **56**
 class **35**
 continue **65**
 convenience **168**
 default **56**
 deinit **185**
 didSet **162**
 do 50, **58**
 else 50
 enum **80**, 202
 extension 159, **174**
 false 52
 for 50, **63**
 func **40**
 if 50
 import **41**, 342
 init **38**
 inout **91**, 195
 internal **35**, 37, 46, 226
 lazy 160, **191**, 193
 let **25**, 324
 mutating **199**, 201, 205
 operator 285
 optional **247**
 override **224**, 344
 postfix **269**, 278
 precedence **285**
 prefix **269**, 278
 private **35**, 46, 226
 protocol **240**
 public **35**, 37, 46, 226
 required 251

keywords (cont.)
 return **40**, 42
 self **39**, 163
 static **204**, 240
 subscript **281**
 super **223**, 344, **344**
 switch 50
 table of Keywords and
 reserved words 351
 table of keywords and
 reserved words 351
 true 52
 typealias 263
 var **25**, 324, 343
 weak **184**
 while 50, **58**
 willSet **162**

L

Label **290**, 304, 329
 Alignment attribute 305,
 332
 Font attribute 305
 Lines attribute 305
 Text attribute 305
 label **354**
 label in a switch **56**
 labeled break statement 354
 exiting a nested loop 355
 labeled continue statement
 355
 terminating a single
 iteration of a labeled
 loop 355
 labeled statement **354**
 lambda 4
 landscape orientation 297,
 300
 last-in, first-out (LIFO)
 order 263
 last property of Array **261**
 launch images 298
 lazy stored property 160,
 191, 192, 193
 cannot have property
 observers 192

leading edge of a view **308**
 left associativity value **284**
 left brace, { **35**
 left justified **62**
 let keyword **25**, 134, 324
Library window 302
 LIFO (last-in, first-out)
 order 263
 line break 22, 23
 line-feed character, \n **24**, 24
 LLVM Compiler 12
 load factor **155**
 local variable **39**, 39, 84
 locale property of class
 NSDateFormatter **182**
 locale-specific currency
 string 41, 322, 348
 locale-specific date String
 182
 locale-specific percentage
 string 346, 347
 localization **313**
 lock GUI components 314
 localize 289
 localizedStringFrom-
 Number method of class
 NSNumberFormatter 186,
 219, 347, 348
 location simulation 12
 lock your components for
 localization 314
 All Properties 314
 entire storyboard 314
 Localizable Properties 314
 Non-localizable Properties
 314
 Nothing 314
 log C function 74
 logical AND, && **66**, 68
 truth table 67
 logical negation, or logical
 NOT (!) operator truth
 table 68
 logical operators **66**
 logical OR, || **66**, **67**
 truth table 67

logical statement
 switch **55**
 Look-and-Feel Observations
 overview xxii
 loop body 58
 loop-continuation condition
 50, 58, 63, 64, 65
 loop statement **50**, 57
 do...while 50, 58
 for 50
 for...in 50, **58**
 while 50, **57**
 looping terminates 58

M

Mac Developer Library Reference 7
 Mac OS X **3**
 Macintosh 3
main.swift **21**
 make your point (game of craps) 77
 map Array elements to new values 115
 map method of an *Optional* 211
 map method of Array **113**, 115
 Master-Detail Application
 template **292**
 max C function 74
 max property of an integer
 type **25**
 max Swift Standard Library
 function **76**
 maximum generic function 258
 Media library **301**
 memberwise copy a value-type object 199
 memberwise initializer for a
 struct **198**, 199, 200
 memory leaks 17, 296
 memory-space/execution-time trade-off 155
 memory utilization 155

message 340
 Metal 292
 method 342
 local variable **39**
 struct 198
 method names
 came case naming 35
 min C function 74
 min property of an integer
 type **25**
 Minimum Font Scale 305, 332
 minus sign (-) formatting
 flag **62**
 missing auto layout
 constraints 334
 Mode attribute 303
 module **46**, **73**
 module (grouping related
 software components) **46**,
 73, 227
 monetary calculations 63,
 185
 monetary values 322
 multidimensional Array
 124, 126
 multiline comment **22**
 nested **22**
 multiple function return
 values 82
 multiplication
 * 28, 29
 assignment operator, *=
 53, 276
 mutable Dictionary 134
 mutate 113
 mutating method in a
 protocol 240
 mutating method of a
 struct **199**, 201, 205

N

namespace 73
 naming convention
 GUI components 337

naming identifiers 26
 Navigator area (Xcode) 16,
 17, 293, 294, 295
 Navigators **294**
 Breakpoint **16**, 294
 Debug **16**, 294
 Issue **16**, 294
 Log **16**, 294
 Project **16**, 18, **294**, 296
 Search **16**, 294
 Symbol **16**, 294
 nested
 Array initializers 125
 for statement 126, 128
 for...in loops 126, 128
 functions 5
 if...else conditional
 statement 51
 multiline comment **22**
 type 5, **202**
 newValue constant received
 by willSet property
 observer **162**
 NeXT Inc. 3
 NeXT Interface Builder 12
 NeXTSTEP operating
 system 3, 323
 nib file 12
 no-argument initializer 168
 non-deterministic random
 numbers **76**
 none associativity value **284**
 not identical to (!==)
 operator 30, **45**
 NSArray class 153, 279, 325
 NSDate class **181**, 182
 NSDateFormatter class **182**,
 184
 dateFormat property
 184
 dateStyle property **182**
 locale property **182**
 stringFromDate method
 182, 184
 timeStyle property **182**

NSDecimalNumber class 34,
63, **185**, 274, 323
 decimalNumberBy-
 Adding method **187**,
 276, 349
 decimalNumberBy-
 DividingBy method
 349
 decimalNumberBy-
 MultiplyingBy
 method **187**, 220, 275,
 349
 initializer 186
 one method **187**
 overloaded operators 275,
 276
 zero method **187**
 NSDictionary class 153,
 279, 325
 NSMutableArray class 153,
 279, 325
 NSMutableDictionary class
 153, 279, 325
 NSMutableString class 279
 NSNumber class 347, 348
 NSNumberFormatter class
41, 323, 347
 localizedStringFromN
 umber method 186,
 219, 347, 348
 numberStyle property
 41
 stringFromNumber
 method **42**, 219
 NSNumberFormatterStyle
 enum 347
 CurrencyStyle
 constant 186, 219
 PercentStyle
 constant 219
 NSString class 153, 279,
 325
 componentsSeparatedB
 yString method **152**

numberStyle property of
 class NSNumberFormatter
41
 numeric keypad 320, 325,
 327
 display 344
 numeric types in Swift 153,
 278, 325

O

@objc keyword 238, 247
 Object library **301**
 object-oriented
 programming (OOP) 215
 Objective-C **3**, 4, 10
 parameter type 345
 property 324
 subclass 342
 superclass 342
 Objective-C protocols 246
 oldValue constant received
 by didSet property
 observer **162**
 one method of class
 NSDecimalNumber **187**
 opacity of a color 328
 OpenGL ES 12, 292
 OpenStep 7
 operating system 3
 operator keyword 285
 operator overloading 5, **265**
 cannot overload = or ?:
 265, 287
 multiplication
 assignment operator,
 *= 276
 operator characters in a
 custom operator 284
 operator head in a custom
 operator 284
 symbols reserved for
 Swift's use 284
 operator precedence 29
 Operator Precedence
 Chart Appendix 352
 rules **29**

operators
 --, predecrement/
 postdecrement **53**
 !, logical NOT **68**
 ?:, ternary conditional
 operator 52
 ... (closed range) **56**, 59,
 107
 . . < (half-open range) **56**,
 59, 103, 107, 108
 *=, multiplication
 assignment operator 53
 /=, division assignment
 operator 53
 &&, logical AND **66**, 67
 %=, remainder assignment
 operator 53
 ++, preincrement/
 postincrement **53**
 +=, addition assignment
 operator **52**
 -=, subtraction
 assignment operator 53
 ||, logical OR 66, **67**
 arithmetic 28
 binary 28
 compound assignment 52
 decrement operator, --
 53, 54
 increment and decrement
 53
 increment, ++ 53
 logical AND, && **66**, 68
 logical operators **66**
 logical OR, || 66, **67**
 multiplication, * 28
 postfix decrement **53**
 postfix increment **53**
 prefix decrement **53**
 prefix increment **53**
 remainder, % 28, 29
 subtraction, - 29
 ternary conditional
 operator, ?: **52**

optional 4
 force unwrap with ! 145, 148
 return value 119
 returned from
 Dictionary subscript 145
 unwrap 148
 optional binding 121, 148, 153, 172, 209, 211, 224, 226, 238
 in a while statement 263
 optional chaining 172, 211, 247
 optional keyword **247**
 optional parameter
 default value **89**
 Optional type 121, **210**
 optional value **42, 119**
 unwrapping 119, 121
 OS X **3**
 Yosemite **3**
 outlet **324**
 create 337, 338
 outlet property name 337
 output 22
 overflow checking 5
 overflow checking arithmetic operators 29
 overflow operators **29**
 &-, overflow subtraction **29**
 &*, overflow multiplication **29**
 &/, overflow division **29**
 &%, overflow remainder **29**
 &+, overflow addition **29**
 overloaded constructors **166**
 overloaded division operator 346
 overloaded function 86, 254
 overloaded methods 86
 overloaded operator function **269**

overloaded operators for complex numbers 273
 overloading
 inout parameter in an overloaded assignment operator function 272
 unary ! operator 266
 overloading generic methods 259
 override a superclass member 250
 override keyword **224, 344**
P
 package 73
Page-Based Application
 template **292**
 parameter
 constant by default 123
 type annotation 38
 var 123
 variadic **128**
 parameter type 345
 pass-by-reference 90
 pass-by-value 90
 pattern in a case 56
 Payable protocol
 declaration 240
 Payable protocol hierarchy
 UML class diagram 239
 PercentStyle constant
 from the enum
 NSNumberFormatterStyle 219, 347
 performance issues 17, 296
 Performance Tips overview
 xxi
 Pin tools in Interface Builder 335
 pixel density 298
 placeholder for a type in generics 254
 playground **11, 14**
 polymorphism **216, 227**
 Portability Tips overview xxii
 portrait orientation 297, 300

postdecrement **53**
 postfix declaration
 modifier **269, 278**
 postfix decrement operator **53**
 postfix increment operator **53**
 postincrement **53**
 pow C function 74
 power of 2 larger than 100 57
 precedence **29, 32**
 arithmetic operators 29
 default value 100 for a new operator 284
 of a custom operator 284
 of built-in operators 284
 Precedence Chart Appendix 352
 precedence context-sensitive keyword **285**
 precondition function **281**
 predecrement **53**
 prefix declaration modifier **269, 278**
 prefix decrement operator **53**
 prefix increment operator **53**
 preincrement **53**
 Preincrementing and postincrementing 54
 principle 195
 principle of least privilege 195
 print a line of text **22**
 print function 23, **23**
 print Swift Standard Library function 73
 Printable protocol 99, 136, 217, 248
 conform to 239
 Printable Swift Standard Library protocol 73
 println function **22, 23**
 println Swift Standard Library function 73

private
 access modifier **35**, 46, 226
 global variable 189
 set for a property 37

private(set) 37

program in the general 216

program in the specific 216

programmatically select a component 325, 344

programming languages
 Objective-C 7

project **14**, 291

project name **293**

Project navigator **16**, 18, **294**, 296

Project Structure group **18**, **296**

property 342
 computed **37**, 163, 324
 constant 36, 324
 didSet observer **162**
 private *setter* 37
 read-only in a protocol 240
 read-write property in a protocol 240
 stored **36**
 stored properties must be initialized 248
 variable 36, 324
 willSet observer **162**

property attribute 184, 343
 unowned **185**
 weak **184**, **343**

property declaration 339

property observer 160, 162, 192
 didSet **162**
 struct 198
 validation 162
 willSet **162**

protocol 217, 228, 231, **238**
 adopt **238**, 241
 adopt more than one 241
 class only **246**

protocol (cont.)
 conform **238**
 convenience initializer in a conforming class 241
 definition 240
 designated initializer in a conforming class 241
 failable initializer 241
 mutating method 240
 Objective-C 246
 read-only property 240
 read-write property 240
 required initializer in a conforming class 240
 requirements 238
 with optional capabilities 246

protocol composition 246, **247**, 259

protocol inheritance 246

protocol keyword **240**

protocols
 Comparable 72, 247, 259
 Equatable 73, 247
 Hashable **134**, 217, 248, 259
 Printable 73, 136, 217, 248
 SignedIntegerType **286**

public
 access modifier **35**, 37, 46, 160, 226
 service **160**

Q

Quick Help inspector **16**, **41**, **295**

R

random numbers
 arc4random UNIX function **76**
 arc4random_uniform UNIX function **76**, 77
 element of chance 76
 generation 116

range operators
 ... (closed range) 107
 ..< (half-open range) 103, 107, 108

raw type of an enum type **81**

raw value of an enum type
 constant **81**

rawValue of an enum constant 204

rawValue property of an enum constant **83**

Read-Eval-Print-Loop (REPL) **11**

read-only computed property 160, 163

read-only property in a protocol 240

read-write property in a protocol 240

real number 27

recent projects 13

recursive factorial 92

recursive function 92

reduce method of Array **114**, 115, 128, 142

refer to an object **45**

reference **45**

reference count 184, 343

reference type **45**, 91, 181

reinventing the wheel 40, 322

remainder 28

remainder compound
 assignment operator, %= 53

remainder operator, % **28**, 29

removeAll method of type Array **104**, 107

removeAll method of type Dictionary **151**

removeAll method of type String **270**

removeAtIndex method of type Array **104**, 107

removeAtIndex method of type String **270**

removeLast method of type
 Array **104**, 107
 removeValueForKey
 method of type
 Dictionary **151**
 REPL (Read-Eval-Print-
 Loop) **11**
 replace a subset of an Array
 108
Report navigator **16**, **294**
 required initializer
 in a class that conforms to
 a protocol 240
 required keyword 251
 requirements of a protocol
 238
Resolve Auto Layout Issues
 334
 responder chain **325**
 return keyword **40**, 42
 return multiple values from a
 function 82
 return type of a method or
 function 40
 reuse 40, 322
 reverse method of Array
 112
 Rhapsody 7
 right align formatted text **62**
 right associativity value **284**
 right brace, } **35**
 rolling two dice 82
 rounding a number 28, 62
 rows of a two-dimensional
 Array 124
 rule of thumb (heuristic) 66
 rules of operator precedence
 29
Run button (Xcode) **35**, 321,
 322

S

savings account 60
 scene **300**
 SceneKit 292
Scheme selector (Xcode) 321

SCM (source-code
 management) repository
 13
 scope of a declaration **84**
 screen cursor 24
 screen-manager program 227
 select a component
 programmatically 325,
 344
 select a subset of an Array
 108
 selecting multiple GUI
 components 332
 self
 to call another initializer
 of the same class 168
 self keyword **39**, 163
 sender of an event **345**
 set accessor of a computed
 property **117**, 178, 179
 setter for a property 36
 shadow a property 39
 sheet 291, 292
 short-circuit evaluation **68**
 shorthand notation for read-
 only computed properties
 163
 shorthand type annotation
 Dictionary 136
 shuffle a deck of cards 116
 side effect 90
 signature of a function **87**
 SignedIntegerType
 protocol **286**
 simulation 76
 simulator 289, **291**, 308
 sin C function 74
 single-entry/single-exit
 control statements **50**
 single-line comment, // **22**
 single-precision floating-
 point number **34**
 Single View Application
 project 325
Single View Application
 template **292**

size class **300**
 Any 327
 Compact Width 327
 Regular Height 327
Size inspector **303**, 336
 Slice type 108
Slider 320
 thumb 320, 330, 331
 thumb position 346
 Value Changed event 340,
 345
 Software Engineering
 Observations overview xxii
 software reuse 215
 sort method of Array **109**
 sort Swift Standard Library
 function 73
 sorted method of Array
 109, 111
 sorted Swift Standard
 Library function 73
 source-code control system
 293
 source-code management
 (SCM) repository 13
 special characters 24
 \, backslash 24
 \' , single-quote 24
 \" , double-quote 24
 \0, null character 24
 \n, line feed 24
 \t, tab 24
 in String literals 24
 specialization (generics) **257**
 SpriteKit 292
 sqrt C function 74
 square brackets, [] 98
 stack 259
 Stack generic type 259
Standard editor (Xcode) **16**,
 294
 Standard Library
 class string 266
 standard output **22**
 standard time format 165

- startIndex property of a String **270**
- statement **23**
- Statements
 - break 57, **64**, 65
 - conditional 49, **49**
 - continue **65**, 355
 - control-statement nesting **50**
 - control-statement stacking **50**
 - do...while 50, **58**
 - for 50, **63**
 - for...in 50, **58**
 - if **29**
 - if...else **50**
 - labeled break **354**, 354
 - labeled continue **355**
 - loop **50**, 57
 - nested if...else 51
 - switch **55**
 - while 50, 57
- static 240
- static keyword **204**, 240
 - type property or type method in a structure or enumeration 190
- static in other object-oriented languages 187
- StepStone 3
- stored property **36**, 37, 117, 160, 223, 230
 - lazy 160, **191**, 193
 - must be initialized 248
 - struct 198
- stored type property 187, **204**
 - in a struct 198
- storyboard **11**, **290**, 300
- stride global function **59**, 60, **103**
 - closed-range **59**
 - half-open range **60**
- String concatenation 42
- String interpolation 5, 160, 238
- String Swift Standard Library type 72
- String type **22**
 - append method **270**
 - concatenation 22
 - conforms to Comparable 268
 - conforms to Equatable 268
 - endIndex property **270**
 - hasPrefix method **270**
 - hasSuffix method **270**
 - insert method **270**
 - interpolation 25, 26
 - isEmpty **347**
 - isEmpty property 269
 - join method **271**
 - literal **22**
 - literals have type String 22
 - removeAll method **270**
 - removeAtIndex method **270**
 - startIndex property **270**
- String type in Swift 153, 278, 325
- stringFromDate method of class NSDateFormatter **182**, 184
- stringFromNumber method of class NSNumberFormatter **42**, 219
- strong reference **184**, 185, **343**
- strong reference cycle 185
- struct
 - default initializer 199
 - initializers in an extension 198, 199
 - keyword 195
 - memberwise initializer **198**, 199, 200
 - mutating method **199**, 201, 205
- structure 195
- structured programming 66
- subclass **215**, 223, 342
 - initializer 223
- subscript
 - struct 198
- subscript keyword **281**
- subtraction 28
 - operator, - 29
- subtraction compound assignment operator, -= 53
- super keyword 223, 344, **344**
- superclass **215**, 342
 - direct **218**
 - indirect **218**
- Swift **4**, 7, 320
 - AnyObject type **279**
 - Apple publications 9
 - sample code 9
- Swift Blog 9
- Swift filename extension (.swift) 21
- Swift Keywords 351
- Swift Programming Language* book 9, 263
- Swift Resource Center 18
- Swift Standard Library **6**
 - Array type 72
 - Boolean and numeric types 72
 - Comparable protocol 72
 - Dictionary type 72
 - Equatable protocol 73
 - max **76**
 - print function 73
 - Printable protocol 73
 - println function 73
 - sort function 73
 - sorted function 73
 - String type 72
- Swift Standard Library Reference* 7

switch conditional
 statement **55**
 case label 56, 57
 default case **56**
 where clause in a case **57**

switch logic 57

switch statement 205
 infer enum constant's type
 205

Symbol navigator **16, 294**

T

tab bar 292

tab character, \t 24

tab stops 24

Tabbed Application template
292

tan C function 74

target-language attribute
 (XLIFF) 316

template 291

termination housekeeping
185

ternary conditional operator,
 ?: 52

Test navigator **16, 294**

Text Field 327, 328
 Editing Changed event
 340, 345
 Keyboard Type attribute
 334

Text property 329

Text property of a Label 329

text property of a UILabel
347

text property of a
 UITextField **346**

thumb of a Slider 320, 330,
 331

thumb position of a Slider
 346

timeStyle property of class
 NSDateFormatter **182**

tokenize a String 152

topmost superclass (base
 class) **220, 248**

trailing closure **111**

trailing edge of a scene 334

trailing edge of a view **308**

true **29, 50, 52**

truncate 28

truth tables
 for operator ! 68
 for operator && 67
 for operator || 67

tuple 4, 40, 55, **82, 104, 210**
 compose 82
 decompose **82, 142**
 ignoring a value during
 decomposition 82
 returning multiple values
 from a function **82**

two-dimensional Array 124

two-phase initialization
 process 223, **249, 250**

type annotation **25, 98**
 parameter 38

type argument **257, 262**

type checking 254

type constraint 134, 258,
259, 286

type inference 4, **25, 136**

type method **187, 189, 190,**
 240
 accessing from a class's
 other members 190
 struct 198

type parameter **140, 256,**
 258, 260
 section **256, 260**

type property **187, 190, 240**
 accessing from a class's
 other members 190
 computed 187, 189
 stored 187, **204**
 stored in a struct 198

type safe 99, 237, 256, 257

type scope 188

typedef keyword 263

types
 Array 72, 153, 278, 325
 Bool **26, 27**

types (cont.)
 Boolean and numeric
 types 72
 Dictionary 72, 153,
 278, 325
 Double **26, 27, 34**
 Float **26, 27, 34, 34**
 Int **25, 27**
 Int16 **25**
 Int32 **25**
 Int64 **25**
 Int8 **25**
 max property of an integer
 type **25**
 min property of an integer
 type **25**
 numeric 153, 278, 325
 Optional 121
 Slice 108
 String **22, 72, 153, 278,**
 325
 UInt16 **26**
 UInt32 **26**
 UInt64 **26**
 UInt8 **26**

U

UIAccessibility protocol
312

UIImageView class **290, 302**

UIKit 7, **323**

UIKit framework **301, 323,**
 324, 342
 UILabel **324**
 UISlider **324**
 UITextField **324**
 UIViewController **324**

UILabel class **290, 324**
 text property **347**

UInt16 type **26**

UInt32 type **26**

UInt64 type **26**

UInt8 type **26**

UISlider class **324**
 value property **346**

UITextField class **324**
 text property **346**

UIViewController class
324, 344

UML (Unified Modeling Language) 218

Unicode Technical Standard #35 for locale-specific formatting 184

Unified Modeling Language (UML) 218

unique ID of a GUI component 314

unique raw values for constants in enum types 202

unit tests 17, 296

universal app **289**, 291, 293, 296

universal-time format 160, 165

unowned property attribute **185**

unqualified name 84

unspecified number of arguments 128

unwrap an optional 148

unwrapping an optional value 119, 121

updateValue method of type Dictionary **150**, 151

uppercase letter 27

user interface (UI) 290

user interface events 340

Using Swift with Cocoa and Objective-C 9, 10, 153, 279

Utilities area (Xcode) 16, 17, 293, 295

V

validate a property with a property observer 162

value binding **57**

Value Changed event for a Slider 340, 345

value in a Dictionary 132

value property of a UISlider **346**

value type 5, 45, 91, 133, 181

value vs. reference types blog post 210

values property of type Dictionary 145

value-type
 memberwise copy 199

var keyword **25**, 324, 343

var parameters 123

variable
 reference type **45**

variable names
 camel case naming 35

variable number of arguments 128

variable property 36, 324

variadic parameter **128**

Version editor (Xcode) 12, **16, 295**

view controller **324**

view debugger 12

view device logs 22

viewDidLoad message **325**

VoiceOver **291**, 311, 313
 enable/disable 311

W

weak keyword **184**

weak property attribute **343**

Welcome to Xcode window **13**

where clause **259**

where clause in a case **57**

while loop statement 50, **57**

while statement
 optional binding 263

white space 22

willSet property observer **162**

workspace window **16**

Wozniak, Steve 3

WWDC (Apple World Wide Developer Conference) xix, 3

X

Xcode 290, **321**
 Assistant editor **16**, 295, 338, 340
 code-completion suggestions 22
 Debug area 16, 17, 293, 295
 Editor area 16, 293, 294
 Jump to Definition 41
 Navigator area 16, 17, 293, 294, 295
 Single View Application project 325
 Standard editor **16**, 294
 Utilities area 16, 17, 293, 295
 Version editor **16**, 295

Xcode 6 **10**

Xcode Groups
 Project Structure **18**
 project structure **296**

Xcode IDE 289

Xcode Libraries
 Code Snippet **301**
 File Template **301**
 Media **301**
 Object **301**

Xcode navigators
 Breakpoint **16**, 294
 Debug **16**, 294
 Find **16**, 294
 Issue **16**, 294
 Project **16**, 18, 294, 296
 Report **16**, 294
 Symbol **16**, 294
 Test **16**, 294

Xcode playground 22

Xcode project 22

Xcode toolbar 17, 295

Xcode Windows

Library 302

Welcome to Xcode **13**

XCTest **12**

Xerox PARC (Palo Alto
Research Center) 3

XLIFF

XML Localization

Interchange File

Format **314**, 315

XML Localization

Interchange File Format
(XLIFF) **314**, 315

Y

Yellow Box API 7

Yosemite (OS X) **3**

Z

zero method of class

NSDecimalNumber **187**

zero-based counting 98