

DEITEL® DEVELOPER SERIES

# C# 2012

## for Programmers

Use with Windows® 7  
or Windows® 8

PAUL DEITEL • HARVEY DEITEL

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# C# 2012 FOR PROGRAMMERS

## FIFTH EDITION

### DEITEL® DEVELOPER SERIES

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**DEITEL**



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*To our review team*

*Shay Friedman*

*Octavio Hernandez*

*Stephen Hustedde*

*José Antonio González Seco*

*Shawn Weisfeld*

*We are grateful for your guidance and expertise.*

*Paul and Harvey Deitel*



# Preface

*“Live in fragments no longer, only connect.”*

—Edgar Morgan Forster

Welcome to Visual C#® 2012 and the world of Microsoft® Windows® and Internet and web programming with Microsoft’s .NET platform. Please read the book’s back cover and inside back cover—these concisely capture the book’s essence. In this Preface we provide more details.

We focus on software engineering best practices. At the heart of the book is the Deitel signature “live-code approach”—concepts are presented in the context of complete working programs, rather than in code snippets. Each complete code example is accompanied by live sample executions. All the source code is available at

[www.deitel.com/books/cs2012fp/](http://www.deitel.com/books/cs2012fp/)

If you have questions as you read the book, we’re easy to reach at [deitel@deitel.com](mailto:deitel@deitel.com)—we’ll respond promptly. For book updates, visit [www.deitel.com/books/cs2012fp](http://www.deitel.com/books/cs2012fp), join our social media communities on Facebook ([www.deitel.com/DeitelFan](http://www.deitel.com/DeitelFan)), Twitter (@deitel), Google+ ([gplus.to/deitel](https://plus.google.com/+deitel)) and LinkedIn ([bit.ly/DeitelLinkedIn](http://bit.ly/DeitelLinkedIn)), and subscribe to the *Deitel® Buzz Online* newsletter ([www.deitel.com/newsletter/subscribe.html](http://www.deitel.com/newsletter/subscribe.html)).

## **Visual C#® 2012, the Visual Studio® 2012 IDE, .NET 4.5, Windows® 7 and Windows® 8**

The new Visual C# 2012 and its associated technologies motivated us to write *C# 2012 for Programmers, 5/e*. These are some of the key features of this new edition:

- *Use with Windows 7, Windows 8 or both.* The book is designed so that you can continue to use Windows 7 now and begin to evolve to Windows 8, if you like, or you can move right to Windows 8. All of the code examples in Chapters 1–22 and 26–33 were tested on *both* Windows 7 and Windows 8. The code examples for the Windows-8-specific chapters—Chapter 23 (Windows 8 UI and XAML), Chapter 24 (Windows 8 Graphics and Multimedia) and Chapter 25 (Building a Windows Phone 8 App)—were tested *only* on Windows 8, because Visual Studio Express 2012 for Windows 8 and Visual Studio Express 2012 for Windows Phone run only on Windows 8.
- *C# and Visual C#.* The C# language has been standardized internationally by ECMA and ISO (the standards document is available free of charge at [bit.ly/ECMA334](http://bit.ly/ECMA334)). This enables other implementations of the language besides Microsoft’s Visual C#, such as Mono ([www.mono-project.com](http://www.mono-project.com)), which runs on Linux systems, iOS (for Apple’s iPhone, iPad and iPod Touch), Google’s Android and Windows.

- *Modular multi-GUI treatment with Windows Forms, Windows 8 UI and WPF.* The book features three different GUI treatments, starting with Windows Forms GUI; later chapters contain treatments of the new Windows 8 UI (user interface) and WPF GUI. Windows 8 UI apps are called *Windows Store apps*. In Chapter 23, you'll learn how to create and test Windows Store apps.
- *Modular treatment of graphics and multimedia with Windows 8 and WPF.* The book features chapters on both the new Windows 8 Graphics and Multimedia (Chapter 24) and WPF Graphics and Multimedia (Chapter 31).
- *Database with LINQ to Entities.* In the previous edition of this book, we discussed LINQ (Language Integrated Query) to SQL (Microsoft's SQL Server database system). Microsoft stopped further development on LINQ to SQL in 2008 in favor of the newer and more robust LINQ to Entities and the ADO.NET Entity Framework, which we've switched to in this edition.
- *SQL Server database.* We use Microsoft's free SQL Server Express 2012 (which installs with the free Visual Studio Express 2012 for Windows Desktop) to present the fundamentals of database programming. Chapters 20–21 and 27 use database and LINQ capabilities to build an address-book desktop app, a web-based guestbook app, a bookstore app and an airline reservation system app.
- *ASP.NET 4.5.* Microsoft's .NET server-side technology, ASP.NET, enables you to create robust, scalable web-based apps. In Chapter 21, you'll build several apps, including a web-based guestbook that uses ASP.NET and the ADO.NET Entity Framework to store data in a database and display data in a web page. The chapter also discusses the IIS Express web server for testing your web apps on your local computer.
- *Building a Windows Phone 8 App.* Windows Phone 8 is Microsoft's latest smart-phone operating system. It features multi-touch support for touchpads and touchscreen devices, enhanced security features and more. In Chapter 25, you'll build a complete working Windows Phone 8 app and test it on the Windows Phone emulator; we discuss how to upload apps to the Windows Phone Store.
- *Building a Windows Azure™ Cloud Computing App.* Windows Azure is a cloud computing platform that allows you to develop, manage and distribute your apps in the cloud. Chapter 29 shows you how to build a Windows Azure app that can store data in the cloud. You'll test your app on the Windows Azure Storage Emulator.
- *Asynchronous programming with `async` and `await`.* Asynchronous programming is simplified in C# 2012 with the new `async` and `await` capabilities. We introduce asynchronous programming with `async` and `await` in Chapter 26. To take advantage of multicore architecture you need to write applications that can process tasks asynchronously. Asynchronous programming is a technique for writing apps containing tasks that can execute asynchronously, which can improve app performance and GUI responsiveness in apps with long-running or compute-intensive tasks.

## Object-Oriented Programming

- *Early-objects approach.* The basic concepts and terminology of object technology are introduced in Chapter 1. In Chapter 2, Dive Into® Visual Studio 2012 Express for Windows Desktop, you'll *visually* manipulate objects, such as labels and images. In Chapter 3, Introduction to C# Apps, you'll write C# *program code* that manipulates *existing* objects. You'll develop your first *customized* classes and objects in Chapter 4.
- *A clear, example-driven presentation of classes, objects, inheritance, polymorphism and interfaces.*
- *Case study: Using the UML to develop an object-oriented design and C# implementation of an Automated Teller Machine (ATM).* The UML™ (Unified Modeling Language™) is the industry-standard graphical language for modeling object-oriented systems. We introduce the UML in the early chapters. Chapters 32 and 33 include a case study on object-oriented design using the UML. We design and implement the software for a simple automated teller machine. We analyze a typical *requirements document* that specifies the system to be built. We determine the *classes* needed to implement that system, the *attributes* the classes need to have, the *behaviors* the classes need to exhibit and we specify how the classes must *interact* with one another to meet the system requirements. From the design we produce a complete working C# implementation. Readers often report a “light bulb moment”—the case study helps them “tie it all together” and understand object orientation more deeply.
- *Multiple programming paradigms.* We discuss *structured programming*, *object-oriented programming*, *generic programming* and some *functional programming*.

## Other Features

- *We use LINQ to query files, databases, XML and collections.* The introductory LINQ to Objects chapter (Chapter 9) will get you started using LINQ technology early. Later in the book, we take a deeper look, using LINQ to Entities (Chapters 20–21 and 27) and LINQ to XML (Chapters 22 and 26).
- *Local type inference.* When you initialize a local variable in its declaration, you can omit the variable's type—the compiler *infers* it from the initializer value.
- *Object initializers.* For new objects, you can use object initializer syntax (similar to array initializer syntax) to assign values to the new object's `public` properties and `public` instance variables.
- *We emphasize the IDE's IntelliSense feature* that helps you write code faster and with fewer errors.
- *Files and strings.*
- *Generics and collections.*
- *Integrated exception handling.* We introduce exception handling early (Chapter 8, Arrays) to watch for attempts to access array elements outside the array's bounds. Chapter 10, Classes and Objects: A Deeper Look, shows how to in-



dicating an exception when a member function receives an invalid argument. We cover the complete details of exception handling in Chapter 13, *Exception Handling: A Deeper Look*.

- *C# XML capabilities.* Extensible Markup Language (XML) is pervasive in the software-development industry and throughout the .NET platform. In Chapter 22, we introduce XML syntax and programmatically manipulate the elements of an XML document using LINQ to XML. XAML is an XML vocabulary that's used to describe graphical user interfaces, graphics and multimedia. We discuss XAML in Chapters 23–24 and 30–31.
- *Web app development with ASP.NET 4.5 and ASP.NET Ajax.* Chapter 27 extends Chapter 21's ASP.NET discussion with a case study on building a password-protected, web-based bookstore app. Also, we introduce in Chapter 27 ASP.NET Ajax controls and use them to add Ajax functionality to web apps to give them a look and feel similar to that of desktop apps.
- *Windows Communication Foundation (WCF) web services.* Web services enable you to package app functionality in a manner that turns the web into a library of reusable services. Chapter 28 includes a case study on building a math question generator web service that's called by a math tutor app.
- *WPF (Windows Presentation Foundation) GUI, graphics and multimedia.* Chapters 30–31 provide an introduction to Windows Presentation Foundation (WPF)—a XAML-based Microsoft framework that preceded Windows 8 UI and integrates GUI, graphics and multimedia capabilities. WPF was designed as a replacement for Windows Forms GUI technologies. We implement a painting app, a text editor, a color chooser, a book-cover viewer, a television video player, various animations, and speech synthesis and recognition apps.

## Training Approach

*C# 2012 for Programmers, 5/e* stresses program clarity and concentrates on building well-engineered software.

*Live-Code Approach.* The book includes hundreds of “live-code” examples—each new concept is presented in the context of a complete working C# app that is immediately followed by one or more actual executions showing the program's inputs and outputs. We include a broad range of example programs selected from computer science, business, simulation, game playing, graphics, multimedia and many other areas.

*Syntax Shading.* For readability, we syntax shade the code, similar to the way most integrated-development environments and code editors syntax color the code. Our syntax-shading conventions are:

```

comments appear like this
keywords appear like this in bold black
constants and literal values appear like this
all other code appears in non-bold black

```

*Code Highlighting.* We place gray rectangles around each program's key code segments.

**Using Fonts for Emphasis.** We place the key terms and the index's page reference for each defining occurrence in ***bold italic*** text for easier reference. We emphasize on-screen components in the **bold Helvetica** font (e.g., the **File** menu) and emphasize C# program text in the Lucida font (e.g., `int x = 5`).

**Web Access.** All of the source-code examples can be downloaded from:

[www.deitel.com/books/cs2012fp](http://www.deitel.com/books/cs2012fp)

**Objectives.** Each chapter begins with a list of chapter objectives.

**Programming Tips.** The book includes hundreds of programming tips and practices that represent the best we've gleaned from a combined eight decades of programming and teaching experience.



### **Good Programming Practice**

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



### **Common Programming Error**

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



### **Error-Prevention Tip**

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



### **Performance Tip**

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



### **Portability Tip**

*The Portability Tips help you write code that will run on a variety of platforms.*



### **Software Engineering Observation**

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



### **Look-and-Feel Observation**

*These observations help you design attractive, user-friendly graphical user interfaces that conform to industry norms.*

## **Obtaining the Software Used in This Book**

We wrote the code examples in *C# 2012 for Programmers, 5/e* using Microsoft's free Visual Studio Express 2012 products, including:

- Visual Studio Express 2012 for Windows Desktop (Chapters 1–20, 22, 26, 29 and 30–33), which includes Visual C# and other Microsoft development tools. This runs on Windows 7 and 8.
- Visual Studio Express 2012 for Web (Chapters 21 and 27–28)
- Visual Studio Express 2012 for Windows 8 (Chapters 23–24)
- Visual Studio Express 2012 for Windows Phone (Chapter 25)

Each of these is available for download at

[www.microsoft.com/visualstudio/eng/products/  
visual-studio-express-products](http://www.microsoft.com/visualstudio/eng/products/visual-studio-express-products)

## ***C# 2012 Fundamentals: Parts I, II, III and IV, Second Edition LiveLessons Video Training***

Our *C# 2012 Fundamentals: Parts I, II, III and IV LiveLessons* video training shows you what you need to know to start building robust, powerful software with C# 2012. It includes approximately 40 hours of expert training synchronized with *C# 2012 for Programmers, 5/e*. For additional information about Deitel LiveLessons video products available on Safari Books Online and other electronic channels, visit

[www.deitel.com/livelessons](http://www.deitel.com/livelessons)

or contact us at [deitel@deitel.com](mailto:deitel@deitel.com).

## **Acknowledgments**

We'd like to thank Abbey Deitel and Barbara Deitel of Deitel & Associates, Inc. for long hours devoted to this project. Abbey co-authored this Preface and Chapter 1 and she and Barbara painstakingly researched the new capabilities of Visual C# 2012, .NET 4.5, Windows 8, Windows Phone 8, Windows Azure and other key topics.

We're fortunate to have worked on this project with the dedicated publishing professionals at Prentice Hall/Pearson. We appreciate the extraordinary efforts and mentorship of our friend and professional colleague Mark L. Taub, Editor-in-Chief of Pearson Technology Group. Carole Snyder did a great job recruiting distinguished members of the C# community to review the manuscript and managing the review process. Chuti Prasertsith designed the cover with creativity and precision. John Fuller does a superb job managing the production of all of our Deitel Developer Series books and LiveLessons video products.

## **Reviewers**

We wish to acknowledge the efforts of the reviewers whose constructive criticisms helped us shape the recent editions of this content. They scrutinized the text and the programs and provided countless suggestions for improving the presentation: Shay Friedman (Microsoft Visual C# MVP), Octavio Hernandez (Microsoft Certified Solutions Developer), Stephen Hustedde (South Mountain College), José Antonio González Seco (Parliament of Andalusia, Spain), Shawn Weisfeld (Microsoft MVP and President and Founder of UserGroup.tv), Huanhui Hu (Microsoft Corporation), Narges Kasiri (Oklahoma State University), Charles Liu (University of Texas at San Antonio), Dr. Hamid R. Nemati

(The University of North Carolina at Greensboro), Jeffrey P. Scott (Blackhawk Technical College), Douglas B. Bock (MCSD.NET, Southern Illinois University Edwardsville), Dan Crevier (Microsoft), Amit K. Ghosh (University of Texas at El Paso), Marcelo Guerra Hahn (Microsoft), Kim Hamilton (Software Design Engineer at Microsoft and co-author of *Learning UML 2.0*), James Edward Keyser (Florida Institute of Technology), Helena Kotas (Microsoft), Chris Lovett (Software Architect at Microsoft), Bashar Lulu (INETA Country Leader, Arabian Gulf), John McIlhinney (Spatial Intelligence; Microsoft MVP 2008 Visual Developer, Visual Basic), Ged Mead (Microsoft Visual Basic MVP, DevCity.net), Anand Mukundan (Architect, Polaris Software Lab Ltd.), Timothy Ng (Microsoft), Akira Onishi (Microsoft), Joe Stagner (Senior Program Manager, Developer Tools & Platforms), Erick Thompson (Microsoft), Jesús Ubaldo Quevedo-Torrero (University of Wisconsin–Parkside, Department of Computer Science) and Zijiang Yang (Western Michigan University).

As you read the book, we'd sincerely appreciate your comments, criticisms and suggestions for improving the text. Please address all correspondence to:

`deitel@deitel.com`

We'll respond promptly. We really enjoyed writing this book—we hope you enjoy reading it!

*Paul Deitel*

*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. Through Deitel & Associates, Inc., he has delivered hundreds of programming courses to industry clients, including Cisco, IBM, Siemens, Sun Microsystems, Dell, Fidelity, NASA at the Kennedy Space Center, the National Severe Storm Laboratory, White Sands Missile Range, Rogue Wave Software, Boeing, SunGard Higher Education, 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.

Paul was named as a Microsoft® Most Valuable Professional (MVP) for C# in 2012. According to Microsoft, “the Microsoft MVP Award is an annual award that recognizes exceptional technology community leaders worldwide who actively share their high quality, real world expertise with users and Microsoft.”



2012/2013 C# MVP

**Dr. Harvey Deitel**, Chairman and Chief Strategy Officer of Deitel & Associates, Inc., has 52 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, all with an emphasis in Computer Science. In the 1960s, through Advanced Computer Techniques and Computer Usage Corporation, he worked on the teams building various IBM operating systems. In the 1970s, he built commercial software systems and more recently committed to a career in Computer Science education. 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 Deitel. The Deitels' publications have earned international recognition, with translations published in Chinese, Korean, Japanese, German, Russian, Spanish, French, Polish, Italian, Portuguese, Greek, Urdu and Turkish. Dr. Deitel has delivered hundreds of programming courses to corporate, academic, government and military clients.

## Deitel® Dive-Into® Series Corporate Training

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# Before You Begin

This section contains information you should review before using this book and instructions to ensure that your computer is set up properly for use with this book.

## *Font and Naming Conventions*

We use fonts to distinguish between features, such as menu names, menu items, and other elements that appear in the program-development environment. Our convention is to emphasize IDE features in a sans-serif bold Helvetica font (for example, **Properties** window) and to emphasize program text in a sans-serif Lucida font (for example, `bool x = true`).

## *Software*

This book uses the following software:

- Microsoft Visual Studio Express 2012 for Windows Desktop
- Microsoft Visual Studio Express 2012 for Web (Chapters 21 and 27–28)
- Microsoft Visual Studio Express 2012 for Windows 8 (Chapters 23–24)
- Microsoft Visual Studio Express 2012 for Windows Phone (Chapter 25)

Each is available free for download at [www.microsoft.com/express](http://www.microsoft.com/express). The Express Editions are fully functional, and there's no time limit for using the software.

## *Hardware and Software Requirements for the Visual Studio 2012 Express Editions*

To install and run the Visual Studio 2012 Express Editions, ensure that your system meets the minimum requirements specified at:

[www.microsoft.com/visualstudio/eng/products/compatibility](http://www.microsoft.com/visualstudio/eng/products/compatibility)

Microsoft Visual Studio Express 2012 for Windows 8 works *only* on Windows 8.

## *Viewing File Extensions*

Several screenshots in *C# 2012 for Programmers*, 5/e display file names with file-name extensions (e.g., .txt, .cs or .png). Your system's settings may need to be adjusted to display file-name extensions. Follow these steps to configure your Windows 7 computer:

1. In the **Start** menu, select **All Programs**, then **Accessories**, then **Windows Explorer**.
2. Press **Alt** to display the menu bar, then select **Folder Options...** from **Windows Explorer's** **Tools** menu.
3. In the dialog that appears, select the **View** tab.
4. In the **Advanced settings:** pane, uncheck the box to the left of the text **Hide extensions for known file types**. [*Note:* If this item is already unchecked, no action needs to be taken.]
5. Click **OK** to apply the setting and close the dialog.

Follow these steps to configure your Windows 8 computer:

1. On the **Start** screen, click the **Desktop** tile to switch to the desktop.
2. On the task bar, click the **File Explorer** icon to open the **File Explorer**.
3. Click the **View** tab, then ensure that the **File name extensions** checkbox is checked.

### *Obtaining the Code Examples*

The examples for *C# 2012 for Programmers, 5/e* are available for download at

[www.deitel.com/books/cs2012fp/](http://www.deitel.com/books/cs2012fp/)

If you're not already registered at our website, go to [www.deitel.com](http://www.deitel.com) and click the **Register** link below our logo in the upper-left corner of the page. Fill in your information. There's no charge to register, and we do not share your information with anyone. We send you only account-management e-mails unless you register separately for our free e-mail newsletter at [www.deitel.com/newsletter/subscribe.html](http://www.deitel.com/newsletter/subscribe.html). *You must enter a valid e-mail address.* After registering, you'll receive a confirmation e-mail with your verification code. Click the link in the confirmation email to go to [www.deitel.com](http://www.deitel.com) and sign in.

Next, go to [www.deitel.com/books/cs2012fp/](http://www.deitel.com/books/cs2012fp/). Click the **Examples** link to download the ZIP archive file to your computer. Write down the location where you save the file—most browsers will save the file into your **Downloads** folder.

Throughout the book, steps that require you to access our example code on your computer assume that you've extracted the examples from the ZIP file and placed them at `C:\Examples`. You can extract them anywhere you like, but if you choose a different location, you'll need to update our steps accordingly. You can extract the ZIP archive file's contents using tools such as WinZip ([www.winzip.com](http://www.winzip.com)), 7-zip ([www.7-zip.org](http://www.7-zip.org)) or the built-in capabilities of **Windows Explorer** on Window 7 or **File Explorer** on Windows 8.

### *Visual Studio Theme*

Visual Studio 2012 has a **Dark** theme (the default) and a **Light** theme. The screen captures shown in this book use the **Light** theme, which is more readable in print. If you'd like to switch to the **Light** theme, in the **TOOLS** menu, select **Options...** to display the **Options** dialog. In the left column, select **Environment**, then select **Light** under **Color theme**. Keep the **Options** dialog open for the next step.

### *Displaying Line Numbers and Configuring Tabs*

Next, you'll change the settings so that your code matches that of this book. To have the IDE display line numbers, expand the **Text Editor** node in the left pane then select **All Languages**. On the right, check the **Line numbers** checkbox. Next, expand the **C#** node in the left pane and select **Tabs**. Make sure that the option **Insert spaces** is selected. Enter **3** for both the **Tab size** and **Indent size** fields. Any new code you add will now use three spaces for each level of indentation. Click **OK** to save your settings.

### *Miscellaneous Notes*

- Some people like to change the workspace layout in the development tools. You can return the tools to their default layouts by selecting **Window > Reset Window Layout**.

- Many of the menu items we use in the book have corresponding icons shown with each menu item in the menus. Many of the icons also appear on one of the toolbars at the top of the development environment. As you become familiar with these icons, you can use the toolbars to help speed up your development time. Similarly, many of the menu items have keyboard shortcuts (also shown with each menu item in the menus) for accessing commands quickly.

You are now ready to begin your Visual C# studies with *C# 2012 for Programmers, 5/e*. We hope you enjoy the book!



