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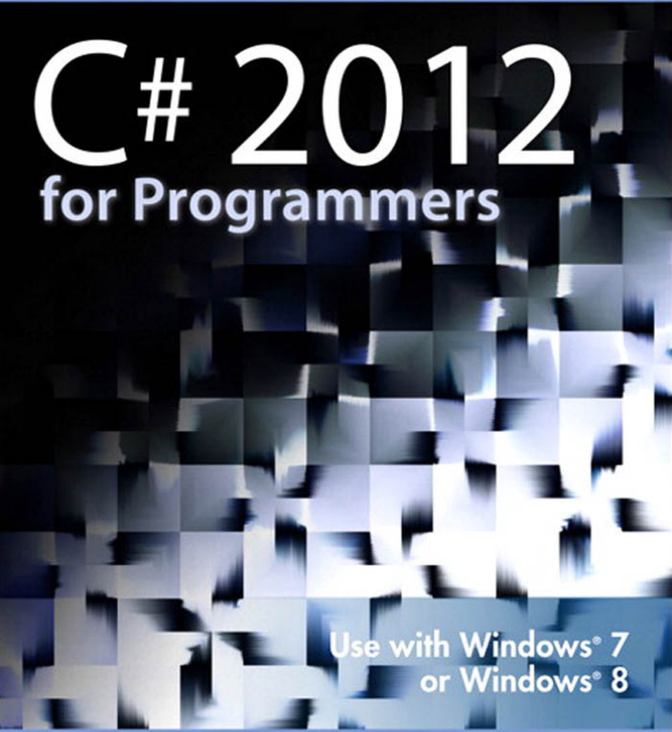

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DEITEL® DEVELOPER SERIES

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Deitel & Associates, Inc.

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To our review team

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We are grateful for your guidance and expertise.

Paul and Harvey Deitel

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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/
```

If you have questions as you read the book, we're easy to reach at `deitel@deitel.com`—we'll respond promptly. For book updates, visit `www.deitel.com/books/cs2012fp`, join our social media communities on Facebook (`www.deitel.com/DeitelFan`), Twitter (`@deitel`), Google+ (`gplus.to/deitel`) and LinkedIn (`bit.ly/DeitelLinkedIn`), and subscribe to the *Deitel® Buzz Online* newsletter (`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`). This enables other implementations of the language besides Microsoft's Visual C#, such as Mono (`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 smartphone 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-

dicate 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
```

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
```

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
```

or contact us at `deitel@deitel.com`.

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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

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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

Deitel & Associates, Inc., founded by Paul Deitel and Harvey Deitel, is an internationally recognized authoring and corporate training organization, specializing in computer programming languages, object technology, mobile app development and Internet and web software technology. The company's 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 Visual C#®, Visual Basic®, C++, Visual C++®, C, Java™, XML®, Python®, object technology, Internet and web programming, Android app development, Objective-C and iOS app development and a growing list of additional programming and software development courses.

Through its 37-year publishing partnership with Prentice Hall/Pearson, Deitel & Associates, Inc., publishes leading-edge programming professional books, college textbooks 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:

```
www.deitel.com/training
```

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

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```
www.informit.com/store/sales.aspx
```

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`. 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
```

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/
```

If you're not already registered at our website, go to `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`. *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` and sign in.

Next, go to `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`), 7-zip (`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!

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3

Introduction to C# Apps

Objectives

In this chapter you'll:

- Input data from the keyboard and output data to the screen.
- Declare and use data of various types.
- Use arithmetic operators.
- Write decision-making statements.
- Use relational and equality operators.

Outline

3.1 Introduction
3.2 A Simple C# App: Displaying a Line of Text
3.3 Creating a Simple App in Visual Studio
3.4 Modifying Your Simple C# App
3.5 Formatting Text with `Console.Write` and `Console.WriteLine`
3.6 Another C# App: Adding Integers
3.7 Arithmetic
3.8 Decision Making: Equality and Relational Operators
3.9 Wrap-Up

3.1 Introduction

We now introduce C# app programming. Most of the C# apps you'll study in this book process information and display results. In this chapter, we introduce **console apps**—these input and output text in a *console window*, which in Windows is known as the **Command Prompt**.

We begin with several examples that simply display messages on the screen. We then demonstrate an app that obtains two numbers from a user, calculates their sum and displays the result. You'll perform various arithmetic calculations and save the results for later use. Many apps contain logic that makes *decisions*—the last example in this chapter demonstrates decision-making fundamentals by comparing numbers and then displaying messages based on the comparison results. For example, the app displays a message indicating that two numbers are equal only if they have the same value.

3.2 A Simple C# App: Displaying a Line of Text

Let's consider a simple app that displays a line of text. The app and its output are shown in Fig. 3.1, which illustrates several important C# language features. Each program we present in this book includes line numbers, which are *not* part of actual C# code. In the Before You Begin section that follows the Preface, we show how to display line numbers for your C# code. We'll soon see that line 10 does the real work of the app—namely, displaying the phrase `Welcome to C# Programming!` on the screen. Let's now do a code walkthrough of the app.

Comments

Line 1

```
    // Fig. 3.1: Welcome1.cs
```

begins with `//`, indicating that the remainder of the line is a **comment**. You'll insert comments to document your apps and improve their readability. The C# compiler ignores comments, so they do *not* cause the computer to perform any action when the app is run. We begin every app with a comment indicating the figure number and the name of the file in which the app is stored.

A comment that begins with `//` is called a **single-line comment**, because it terminates at the end of the line on which it appears. A `//` comment also can begin in the middle of a line and continue until the end of that line (as in lines 7, 11 and 12).

```
 1  // Fig. 3.1: Welcome1.cs
 2  // Text-displaying app.
 3  using System;
 4
 5  public class Welcome1
 6  {
 7     // Main method begins execution of C# app
 8     public static void Main( string[] args )
 9     {
10        Console.WriteLine( "Welcome to C# Programming!" );
11     } // end Main
12  } // end class Welcome1
```

```
Welcome to C# Programming!
```

Fig. 3.1 | Text-displaying app.

Delimited comments such as

```
/* This is a delimited comment.
   It can be split over many lines */
```

can be split over several lines. This type of comment begins with the delimiter `/*` and ends with the delimiter `*/`. All text between the delimiters is ignored by the compiler.

Common Programming Error 3.1

Forgetting one of the delimiters of a delimited comment is a syntax error.

Line 2

```
// Text-displaying app.
```

is a single-line comment that describes the purpose of the app.

`using` Directive

Line 3

```
using System;
```

is a **`using` directive** that tells the compiler where to look for a class that's used in this app. A great strength of Visual C# is its rich set of predefined classes that you can *reuse* rather than "reinventing the wheel." These classes are organized under **namespaces**—named collections of related classes. Collectively, .NET's namespaces are referred to as the **.NET Framework Class Library**. Each `using` directive identifies a namespace containing predefined classes that a C# app should be able to use. The `using` directive in line 3 indicates that this example intends to use classes from the `System` namespace, which contains the predefined `Console` class (discussed shortly) used in line 10, and many other useful classes.

Error-Prevention Tip 3.1

Forgetting to include a `using` directive for a namespace that contains a class used in your app typically results in a compilation error, containing a message such as "`The name 'Console' does not exist in the current context.`"

For each new .NET class we use, we indicate the namespace in which it's located. This information is important, because it helps you locate descriptions of each class in the **.NET documentation**. A web-based version of this documentation can be found at

```
msdn.microsoft.com/en-us/library/ms229335.aspx
```

This can also be accessed via the **Help** menu. You can click the name of any .NET class or method, then press the *F1* key to get more information. Finally, you can learn about the contents of a given namespace by going to

```
msdn.microsoft.com/namespace
```

So, `msdn.microsoft.com/System` takes you to namespace `System`'s documentation.

Blank Lines and Whitespace

Line 4 is simply a *blank line*. Blank lines and space characters make code easier to read, and together with tab characters are known as **whitespace**. Space characters and tabs are known specifically as **whitespace characters**. Whitespace is ignored by the compiler.

Class Declaration

Line 5

```
public class Welcome1
```

begins a **class declaration** for the class `Welcome1`. Every app consists of at least one class declaration that's defined by you. These are known as **user-defined classes**. The **`class` keyword** introduces a class declaration and is immediately followed by the **class name** (`Welcome1`). Keywords (sometimes called **reserved words**) are reserved for use by C# and are always spelled with all lowercase letters. The complete list of C# keywords is shown in Fig. 3.2.

C# Keywords and contextual keywords				
abstract	as	base	bool	break
byte	case	catch	char	checked
class	const	continue	decimal	default
delegate	do	double	else	enum
event	explicit	extern	false	finally
fixed	float	for	foreach	goto
if	implicit	in	int	interface
internal	is	lock	long	namespace
new	null	object	operator	out
override	params	private	protected	public
readonly	ref	return	sbyte	sealed
short	sizeof	stackalloc	static	string
struct	switch	this	throw	true
try	typeof	uint	ulong	unchecked
unsafe	ushort	using	virtual	void
volatile	while			

Fig. 3.2 | C# keywords and contextual keywords. (Part 1 of 2.)

C# Keywords and contextual keywords

Contextual Keywords

`add`	`alias`	`ascending`	`async`	`await`
`by`	`descending`	`dynamic`	`equals`	`from`
`get`	`global`	`group`	`into`	`join`
`let`	`on`	`orderby`	`partial`	`remove`
`select`	`set`	`value`	`var`	`where`
`yield`				

Fig. 3.2 | C# keywords and contextual keywords. (Part 2 of 2.)

Class Name Convention

By convention, all class names begin with a capital letter and capitalize the first letter of each word they include (e.g., `SampleClassName`). This convention is known as **upper camel casing**. A class name is an **identifier**—a series of characters consisting of letters, digits and underscores (_) that does not begin with a digit and does not contain spaces. Some valid identifiers are `Welcome1`, `identifier`, `_value` and `m_inputField1`. The name `7button` is *not* a valid identifier because it begins with a digit, and the name `input field` is *not* a valid identifier because it contains a space. Normally, an identifier that does not begin with a capital letter is not the name of a class. C# is **case sensitive**—that is, uppercase and lowercase letters are distinct, so `a1` and `A1` are different (but both valid) identifiers.[1]

Good Programming Practice 3.1

By convention, always begin a class name's identifier with a capital letter and start each subsequent word in the identifier with a capital letter.

Common Programming Error 3.2

C# is case sensitive. Not using the proper uppercase and lowercase letters for an identifier normally causes a compilation error.

`public` *Class*

In Chapters 3–9, every class we define begins with the keyword **`public`**. For now, we'll simply require this keyword. You'll learn more about classes in Chapter 10. When you save your `public` class declaration in a file, the file name is usually the class name followed by the `.cs` file-name extension. For our app, the file name is `Welcome1.cs`.

Good Programming Practice 3.2

By convention, a file that contains a single `public` class should have a name that's identical to the class name (plus the `.cs` extension) in both spelling and capitalization.

1. Identifiers may also be preceded by the `@` character. This indicates that a word should be interpreted as an identifier, even if it's a keyword (e.g., `@int`). This allows C# code to use code written in other .NET languages where an identifier might have the same name as a C# keyword. The **contextual keywords** in Fig. 3.2 can be used as identifiers outside the contexts in which they're keywords, but for clarity this is not recommended.

Body of a Class Declaration

A **left brace** (in line 6 in Fig. 3.1), `{`, begins the **body** of every class declaration. A corresponding **right brace** (in line 12), `}`, must end each class declaration. Lines 7–11 are indented. This indentation is a *spacing convention*. We define each spacing convention as a *Good Programming Practice*.

Good Programming Practice 3.3

Indent the entire body of each class declaration one "level" of indentation between the left and right braces that delimit the body of the class. This format emphasizes the class declaration's structure and makes it easier to read. You can let the IDE format your code by selecting **Edit > Advanced > Format Document**.

Common Programming Error 3.3

It's a syntax error if braces do not occur in matching pairs.

`Main` Method

Line 7

```
    // Main method begins execution of C# app
```

is a comment indicating the purpose of lines 8–11 of the app. Line 8

```
    public static void Main( string[] args )
```

is the starting point of every app. The **parentheses** after the identifier `Main` indicate that it's an app building block called a **method**. Class declarations normally contain one or more methods. Method names usually follow the same capitalization conventions used for class names. For each app, one of the methods in a class *must* be called `Main` (which is typically defined as shown in line 8); otherwise, the app will not execute. Methods are able to perform tasks and return information when they complete their tasks. Keyword **`void`** (line 8) indicates that this method will *not* return any information after it completes its task. Later, we'll see that many methods do return information. You'll learn more about methods in Chapters 4 and 7. We discuss the contents of `Main`'s parentheses in Chapter 8. For now, simply mimic `Main`'s first line in your apps.

Body of a Method Declaration

The left brace in line 9 begins the **body of the method declaration**. A corresponding right brace must end the method's body (line 11). Line 10 in the body of the method is indented between the braces.

Displaying a Line of Text

Line 10

```
    Console.WriteLine( "Welcome to C# Programming!" );
```

instructs the computer to **perform an action**—namely, to display the **string** of characters between the double quotation marks, which *delimit* the string. A string is sometimes called a **character string**, a **message** or a **string literal**. We refer to them simply as strings. Whitespace characters in strings are *not* ignored by the compiler.

Class **`Console`** provides **standard input/output** capabilities that enable apps to read and display text in the console window from which the app executes. The **`Console.WriteLine` method** displays a line of text in the console window. The string in the parentheses in line 10 is the **argument** to the method. Method `Console.WriteLine` performs its task by displaying its argument in the console window. When `Console.WriteLine` completes its task, it positions the **screen cursor** (the blinking symbol indicating where the next character will be displayed) at the beginning of the next line in the console window. This movement of the cursor is similar to what happens when a user presses the *Enter* key while typing in a text editor—the cursor moves to the beginning of the next line in the file.

Statements

The entire line 10, including `Console.WriteLine`, the parentheses, the argument `"Welcome to C# Programming!"` in the parentheses and the **semicolon** (`;`), is called a **statement**. Most statements end with a semicolon. When the statement in line 10 executes, it displays the message `Welcome to C# Programming!` in the console window. A method is typically composed of one or more statements that perform the method's task.

Matching Left (`{`) and Right (`}`) Braces

You may find it difficult when reading or writing an app to match the left and right braces (`{` and `}`) that delimit the body of a class declaration or a method declaration. To help, you can include a comment after each closing right brace (`}`) that ends a method declaration and after each closing right brace that ends a class declaration. For example, line 11

```
      } // end Main
```

specifies the closing right brace of method `Main`, and line 12

```
   } // end class Welcome1
```

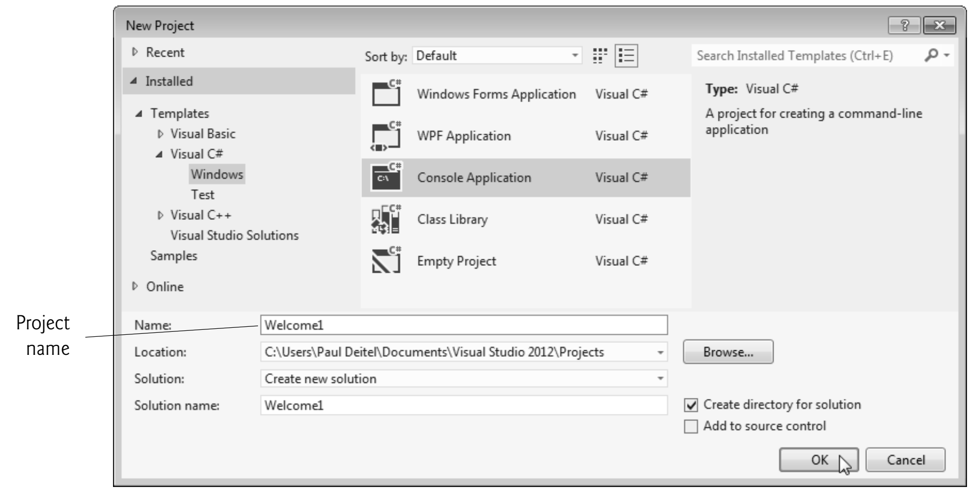
specifies the closing right brace of class `Welcome1`. Each of these comments indicates the method or class that the right brace terminates. Visual Studio can help you locate matching braces in your code. Simply place the cursor immediately in front of the left brace or immediately after the right brace, and Visual Studio will highlight both.

3.3 Creating a Simple App in Visual Studio

Now that we've presented our first console app (Fig. 3.1), we provide a step-by-step explanation of how to create, compile and execute it using Visual Studio 2012 Express for Windows Desktop, which we'll refer to simply as Visual Studio from this point forward.

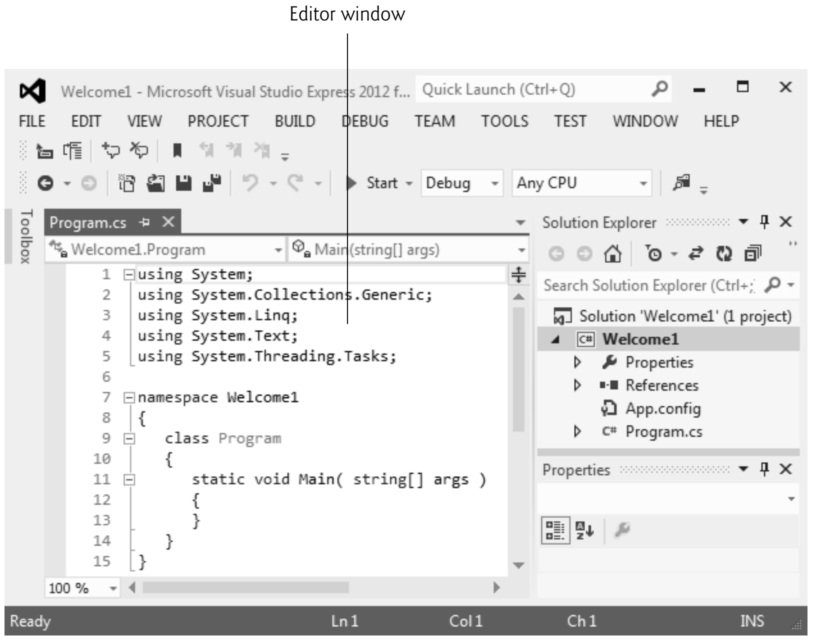
Creating the Console App

After opening Visual Studio, select **FILE > New Project…** to display the **New Project** dialog (Fig. 3.3). At the left side of the dialog, under **Installed > Templates > Visual C#** select the **Windows** category, then in the middle of the dialog select the **Console Application** template. In the dialog's **Name** field, type `Welcome1`, then click **OK** to create the project. By default, the project's folder will be placed in your account's `Documents` folder under `Visual Studio 2012\Projects`. The IDE now contains the open console app, as shown in Fig. 3.4. The editor window already contains some code provided by the IDE. Some of



Name: Welcome1
Location: C:\Users\Paul Deitel\Documents\Visual Studio 2012\Projects
Solution: Create new solution
Solution name: Welcome1
☑ Create directory for solution
☐ Add to source control

Fig. 3.3 | Creating a **Console Application** with the **New Project** dialog.



```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace Welcome1
{
    class Program
    {
        static void Main( string[] args )
        {
        }
    }
}
```

Fig. 3.4 | IDE with an open console app.

this code is similar to that of Fig. 3.1. Some is not, and uses features that we have not yet discussed. The IDE inserts this extra code to help organize the app and to provide access to some common classes in the .NET Framework Class Library—at this point in the book, this code is neither required nor relevant to the discussion of this app; delete all of it.

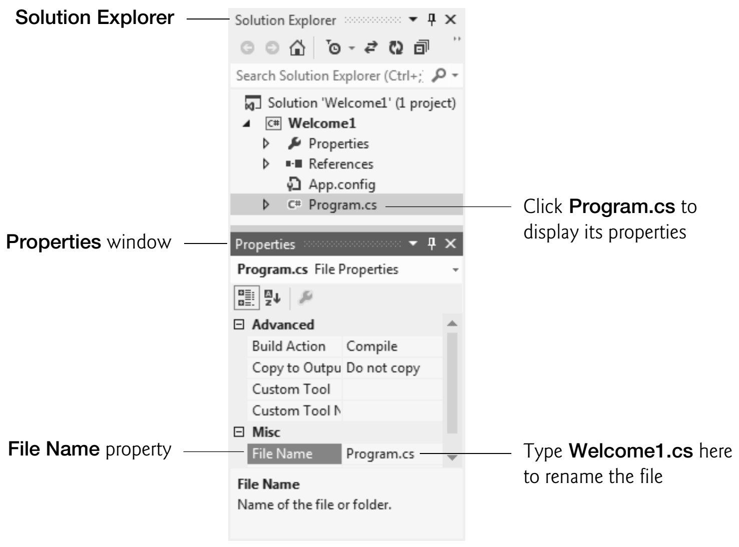
The code coloring scheme used by the IDE is called **syntax-color highlighting** and helps you visually differentiate app elements. For example, keywords appear in blue and comments appear in green. We syntax-shade our code similarly—bold for keywords, gray for comments, bold gray for literals and constants, and black for other text. One example of a literal is the string passed to `Console.WriteLine` in line 10 of Fig. 3.1. You can customize the colors shown in the code editor by selecting **Tools > Options…**. This displays the **Options** dialog. Then expand the **Environment** node and select **Fonts and Colors**. Here you can change the colors for various code elements.

Configuring the Editor Window

Visual Studio provides many ways to personalize your coding experience. In the Before You Begin section that follows the Preface, we show how to configure the IDE to display line numbers at the left side of the editor window and how to specify indent sizes that match our code examples.

Changing the Name of the App File

For the apps we create in this book, we change the default name of the source-code file (i.e., `Program.cs`) to a more descriptive name. To rename the file, click `Program.cs` in the **Solution Explorer** window. This displays the app file's properties in the **Properties** window (Fig. 3.5). Change the **File Name property** to `Welcome1.cs` and press *Enter*.


Solution Explorer
Properties window
File Name property
Click Program.cs to display its properties
Type Welcome1.cs here to rename the file
Solution Explorer
Search Solution Explorer (Ctrl+;
Solution 'Welcome1' (1 project)
Welcome1
Properties
References
App.config
Program.cs
Properties
Program.cs File Properties

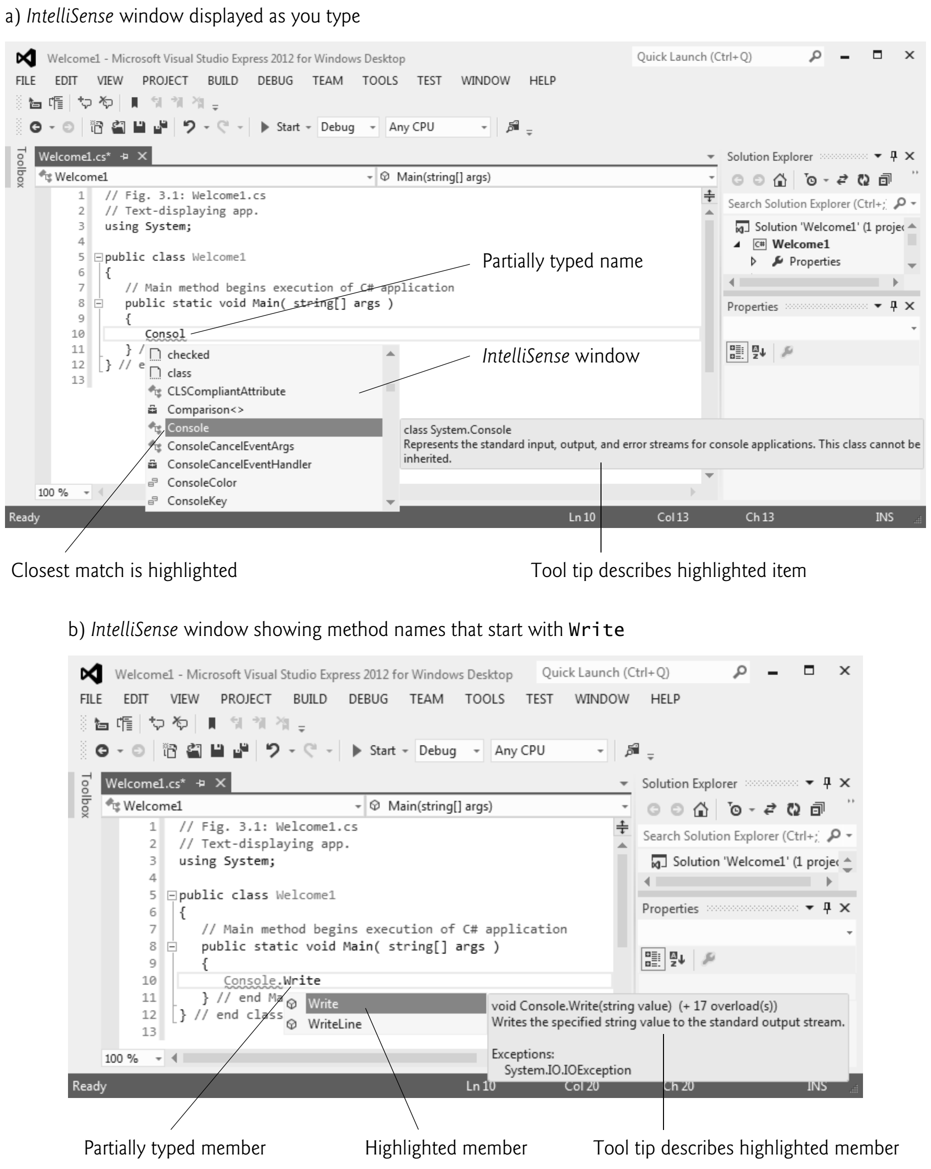
Advanced
Build Action Compile
Copy to Outpu Do not copy
Custom Tool
Custom Tool N
Misc
File Name Program.cs

File Name
Name of the file or folder.

Fig. 3.5 | Renaming the program file in the **Properties** window.

Writing Code and Using IntelliSense

In the editor (Fig. 3.4), replace the IDE-generated code with the code in Fig. 3.1. As you begin typing `Console` (line 10), an ***IntelliSense*** window is displayed (Fig. 3.6(a)). As you type, *IntelliSense* lists various items that start with or contain the letters you've typed so far. *IntelliSense* also displays a tool tip containing a description of the first matching item. You can


a) *IntelliSense* window displayed as you type
Welcome1 - Microsoft Visual Studio Express 2012 for Windows Desktop
Quick Launch (Ctrl+Q)
FILE EDIT VIEW PROJECT BUILD DEBUG TEAM TOOLS TEST WINDOW HELP
Start Debug Any CPU
Welcome1.cs*
Welcome1
Main(string[] args)
Solution Explorer
Search Solution Explorer (Ctrl+;
Solution 'Welcome1' (1 projec
Welcome1
Properties
checked
class
CLSCompliantAttribute
Comparison<>
Console
ConsoleCancelEventArgs
ConsoleCancelEventHandler
ConsoleColor
ConsoleKey
100 %
Ready
Ln 10
Col 13
Ch 13
INS
Partially typed name
IntelliSense window
Closest match is highlighted
Tool tip describes highlighted item
b) *IntelliSense* window showing method names that start with `Write`
Write
WriteLine
Ln 10
Col 20
Ch 20
Partially typed member
Highlighted member
Tool tip describes highlighted member

```
// Fig. 3.1: Welcome1.cs
// Text-displaying app.
using System;

public class Welcome1
{
   // Main method begins execution of C# application
   public static void Main( string[] args )
   {
      Consol
```

class System.Console
Represents the standard input, output, and error streams for console applications. This class cannot be inherited.

```
// Fig. 3.1: Welcome1.cs
// Text-displaying app.
using System;

public class Welcome1
{
   // Main method begins execution of C# application
   public static void Main( string[] args )
   {
      Console.Write
   } // end Main
} // end class
```

void Console.Write(string value) (+ 17 overload(s))
Writes the specified string value to the standard output stream.

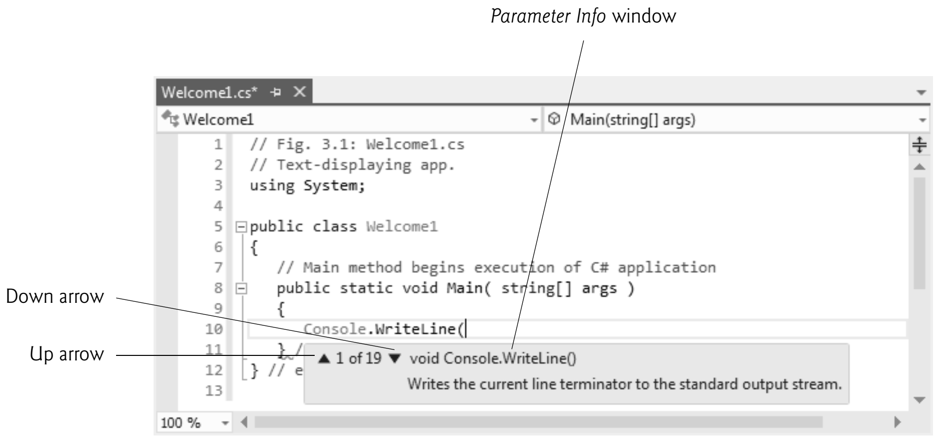
Exceptions:
System.IO.IOException

Fig. 3.6 | *IntelliSense*.

either type the complete item name (e.g., `Console`), double click the item name in the member list or press the *Tab* key to complete the name. Once the complete name is provided, the *IntelliSense* window closes. While the *IntelliSense* window is displayed, pressing the *Ctrl* key makes the window transparent so you can see the code behind the window.

When you type the dot (`.`) after `Console`, the *IntelliSense* window reappears and shows only the members of class `Console` that can be used on the right of the dot (Fig. 3.6(b)). When you type the open parenthesis character, `(`, after `Console.WriteLine`, the ***Parameter***

Info window is displayed (Fig. 3.7). This window contains information about the method's parameters. A class can define several methods that have the *same* name, as long as they have *different* numbers and/or types of parameters—a concept known as *overloaded methods*. These methods normally all perform similar tasks. The *Parameter Info* window indicates how many versions of the selected method are available and provides up and down arrows for scrolling through the different versions. For example, there are 19 versions of the `WriteLine` method—we use one of these in our app. The *Parameter Info* window is one of many features provided by the IDE to facilitate app development. In the next several chapters, you'll learn more about the information displayed in these windows. The *Parameter Info* window is especially helpful when you want to see the different ways in which a method can be used. From the code in Fig. 3.1, we already know that we intend to display one string with `WriteLine`, so, because you know exactly which version of `WriteLine` you want to use, you can simply close the *Parameter Info* window by pressing the *Esc* key.



```
// Fig. 3.1: Welcome1.cs
// Text-displaying app.
using System;

public class Welcome1
{
   // Main method begins execution of C# application
   public static void Main( string[] args )
   {
      Console.WriteLine(|
      } /
} // e
```

▲ 1 of 19 ▼ void Console.WriteLine()
Writes the current line terminator to the standard output stream.

Fig. 3.7 | *Parameter Info* window.

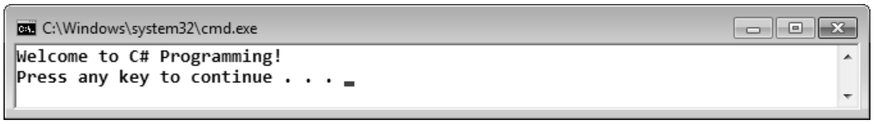
Saving the App

After you type the app's code, select **FILE > Save All** to save the project.

Compiling and Running the App

You're now ready to compile and execute your app. Depending on the project's type, the compiler may compile the code into files with the **`.exe`** (**executable**) **extension**, the **`.dll`** (**dynamically linked library**) **extension** or one of several other extensions. Such files are called **assemblies** and are the packaging units for compiled C# code. These assemblies contain the Microsoft Intermediate Language (MSIL) code for the app.

To compile the app, select **BUILD > Build Solution**. If the app contains no syntax errors, this will create an executable file (named `Welcome1.exe`, in one of the project's subdirectories). To execute it, type *Ctrl* + *F5*, which invokes the `Main` method (Fig. 3.1). If you attempt to run the app before building it, the IDE will build the app first, then run it only if there are no compilation errors. The statement in line 10 of `Main` displays `Welcome to C# Programming!`. Figure 3.8 shows the results of executing this app, displayed in a console (**Command Prompt**) window. Leave the app's project open in Visual Studio; we'll go back to it later in



```
Welcome to C# Programming!
Press any key to continue . . .
```

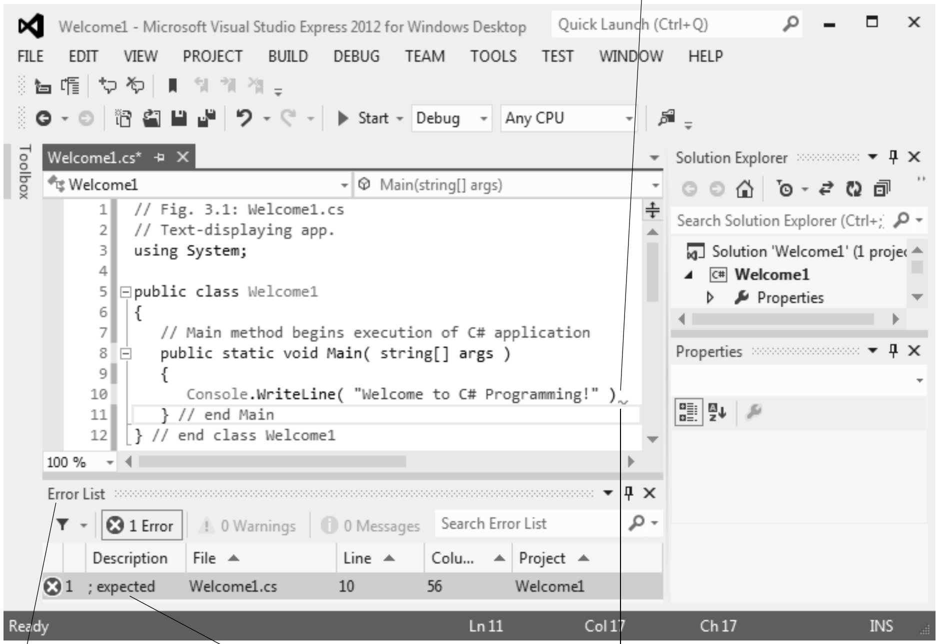
Fig. 3.8 | Executing the app shown in Fig. 3.1.

this section. [*Note:* The console window normally has a black background and white text. We reconfigured it to have a white background and black text for readability. If you'd like to do this, click the ■ icon in the upper-left corner of the console window, then select **Properties**. You can change the colors in the **Colors** tab of the dialog that appears.]

Syntax Errors, Error Messages and the Error List *Window*

Go back to the app in Visual Studio. As you type code, the IDE responds either by applying syntax-color highlighting or by generating a **syntax error**, which indicates a violation of Visual C#'s rules for creating correct apps. Syntax errors occur for various reasons, such as missing parentheses and misspelled keywords.

When a syntax error occurs, the IDE underlines the location of the error with a red squiggly line and provides a description of it in the **Error List window** (Fig. 3.9). If the


Intentionally omitted semicolon (syntax error)
Welcome1 - Microsoft Visual Studio Express 2012 for Windows Desktop
Quick Launch (Ctrl+Q)
FILE EDIT VIEW PROJECT BUILD DEBUG TEAM TOOLS TEST WINDOW HELP
Start
Debug
Any CPU
Toolbox
Welcome1.cs*
Welcome1
Main(string[] args)
Solution Explorer
Search Solution Explorer (Ctrl+;
Solution 'Welcome1' (1 projec
Welcome1
Properties
Properties
100 %
Error List
1 Error
0 Warnings
0 Messages
Search Error List
Ready
Ln 11
Col 17
Ch 17
INS
Error List window
Error description(s)
Squiggly underline indicates a syntax error

```
// Fig. 3.1: Welcome1.cs
// Text-displaying app.
using System;

public class Welcome1
{
   // Main method begins execution of C# application
   public static void Main( string[] args )
   {
      Console.WriteLine( "Welcome to C# Programming!" )
   } // end Main
} // end class Welcome1
```

	Description	File	Line	Colu...	Project
1	; expected	Welcome1.cs	10	56	Welcome1

Fig. 3.9 | Syntax error indicated by the IDE.

Error List window is not visible in the IDE, select **VIEW > Error List** to display it. In Figure 3.9, we intentionally omitted the semicolon at the end of the statement in line 10. The error message indicates that the semicolon is missing. You can double click an error message in the **Error List** to jump to the error's location in the code.

Error-Prevention Tip 3.2

One syntax error can lead to multiple entries in the **Error List** *window. Each error that you address could eliminate several subsequent error messages when you recompile your app. So when you see an error you know how to fix, correct it and recompile—this may make several other errors disappear.*

3.4 Modifying Your Simple C# App

This section continues our introduction to C# programming with two examples that modify the example of Fig. 3.1.

Displaying a Single Line of Text with Multiple Statements

Class `Welcome2`, shown in Fig. 3.10, uses two statements to produce the same output as that shown in Fig. 3.1. From this point forward, we highlight the new and key features in each code listing, as shown in lines 10–11 of Fig. 3.10.

```
 1  // Fig. 3.10: Welcome2.cs
 2  // Displaying one line of text with multiple statements.
 3  using System;
 4
 5  public class Welcome2
 6  {
 7     // Main method begins execution of C# app
 8     public static void Main( string[] args )
 9     {
10        Console.Write( "Welcome to " );
11        Console.WriteLine( "C# Programming!" );
12     } // end Main
13  } // end class Welcome2
```

```
Welcome to C# Programming!
```

Fig. 3.10 | Displaying one line of text with multiple statements.

The app is almost identical to Fig. 3.1. We discuss the changes here. Line 2

```
// Displaying one line of text with multiple statements.
```

states the purpose of this app. Line 5 begins the `Welcome2` class declaration.

Lines 10–11 of method `Main`

```
Console.Write( "Welcome to " );
Console.WriteLine( "C# Programming!" );
```

display one line of text in the console window. The first statement uses `Console`'s method **`Write`** to display a string. Unlike `WriteLine`, after displaying its argument, `Write` does *not* position the screen cursor at the beginning of the next line in the console window—the next character the app displays will appear immediately after the last character that `Write` displays. Thus, line 11 positions the first character in its argument (the letter "`C`") immediately *after* the last character that line 10 displays (the space character before the string's closing double-quote character). Each `Write` statement resumes displaying characters from where the last `Write` statement displayed its last character.

Displaying Multiple Lines of Text with a Single Statement

A single statement can display multiple lines by using newline characters, which indicate to `Console` methods `Write` and `WriteLine` when they should position the screen cursor to the beginning of the next line in the console window. Like space characters and tab characters, newline characters are whitespace characters. The app of Fig. 3.11 outputs four lines of text, using newline characters to indicate when to begin each new line.

```
 1  // Fig. 3.11: Welcome3.cs
 2  // Displaying multiple lines with a single statement.
 3  using System;
 4
 5  public class Welcome3
 6  {
 7     // Main method begins execution of C# app
 8     public static void Main( string[] args )
 9     {
10        Console.WriteLine( "Welcome\nto\nC#\nProgramming!" );
11     } // end Main
12  } // end class Welcome3
```

```
Welcome
to
C#
Programming!
```

Fig. 3.11 | Displaying multiple lines with a single statement.

Most of the app is identical to the apps of Fig. 3.1 and Fig. 3.10, so we discuss only the changes here. Line 2

```
// Displaying multiple lines with a single statement.
```

states the purpose of this app. Line 5 begins the `Welcome3` class declaration.

Line 10

```
Console.WriteLine( "Welcome\nto\nC#\nProgramming!" );
```

displays four separate lines of text in the console window. Normally, the characters in a string are displayed exactly as they appear in the double quotes. Note, however, that the two characters \ and `n` (repeated three times in the statement) do *not* appear on the screen. The **backslash** (\) is called an **escape character**. It indicates to C# that a "special character" is in the string. When a backslash appears in a string of characters, C# combines the next character with the backslash to form an **escape sequence.** The escape sequence `\n` represents the **newline character**. When a newline character appears in a string being output with `Console` methods, the newline character causes the screen cursor to move to the beginning of the next line in the console window. Figure 3.12 lists several common escape sequences and describes how they affect the display of characters in the console window.

Escape sequence	Description
`\n`	Newline. Positions the screen cursor at the beginning of the next line.
`\t`	Horizontal tab. Moves the screen cursor to the next tab stop.
`\"`	Double quote. Used to place a double-quote character (") in a string—e,g., `Console.Write( "\"in quotes\"" );` displays `"in quotes"`.
`\r`	Carriage return. Positions the screen cursor at the beginning of the current line—does not advance the cursor to the next line. Any characters output after the carriage return overwrite the characters previously output on that line.
`\\`	Backslash. Used to place a backslash character in a string.

Fig. 3.12 | Some common escape sequences.

3.5 Formatting Text with Console.Write and Console.WriteLine

`Console` methods `Write` and `WriteLine` also have the capability to display formatted data. Figure 3.13 outputs the strings `"Welcome to"` and `"C# Programming!"` with `WriteLine`.

```
 1  // Fig. 3.13: Welcome4.cs
 2  // Displaying multiple lines of text with string formatting.
 3  using System;
 4
 5  public class Welcome4
 6  {
 7     // Main method begins execution of C# app
 8     public static void Main( string[] args )
 9     {
10        Console.WriteLine( "{0}\n{1}", "Welcome to", "C# Programming!" );
11     } // end Main
12  } // end class Welcome4
```

```
Welcome to
C# Programming!
```

Fig. 3.13 | Displaying multiple lines of text with string formatting.

Line 10

```
    Console.WriteLine( "{0}\n{1}", "Welcome to", "C# Programming!" );
```

calls method `Console.WriteLine` to display the app's output. The method call specifies three arguments. When a method requires multiple arguments, the arguments are separated with **commas** (`,`)—this is known as a **comma-separated list**.

Good Programming Practice 3.4

Place a space after each comma (,) in an argument list to make apps more readable.

Most statements end with a semicolon (`;`). Therefore, line 10 represents only one statement. Large statements can be split over many lines, but there are some restrictions.

Common Programming Error 3.4

Splitting a statement in the middle of an identifier or a string is a syntax error.

Format Strings and Format Items

Method `WriteLine`'s first argument is a **format string** that may consist of **fixed text** and **format items**. Fixed text is output by `WriteLine`, as in Fig. 3.1. Each format item is a placeholder for a value. Format items also may include optional formatting information.

Format items are enclosed in curly braces and contain characters that tell the method which argument to use and how to format it. For example, the format item `{0}` is a *placeholder* for the first additional argument (because C# starts counting from 0), `{1}` is a *placeholder* for the second, and so on. The format string in line 10 specifies that `WriteLine` should output two arguments and that the first one should be followed by a newline character. So this example substitutes `"Welcome to"` for the `{0}` and `"C# Programming!"` for the `{1}`. The output shows that two lines of text are displayed. Because braces in a formatted string normally indicate a placeholder for text substitution, you must type two left braces (`{{`) or two right braces (`}}`) to insert a single left or right brace into a formatted string, respectively. We introduce additional formatting features as they're needed in our examples.

3.6 Another C# App: Adding Integers

Our next app reads (or inputs) two **integers** (whole numbers, like –22, 7, 0 and 1024) typed by a user at the keyboard, computes the sum of the values and displays the result. This app must keep track of the numbers supplied by the user for the calculation later in the app. Apps remember numbers and other data in the computer's memory and access that data through app elements called **variables**. The app of Fig. 3.14 demonstrates these concepts. In the sample output, we highlight data the user enters at the keyboard in bold.

```
// Fig. 3.14: Addition.cs
// Displaying the sum of two numbers input from the keyboard.
using System;

public class Addition
{
   // Main method begins execution of C# app
   public static void Main( string[] args )
   {
      int number1; // declare first number to add
      int number2; // declare second number to add
      int sum; // declare sum of number1 and number2
```

Fig. 3.14 | Displaying the sum of two numbers input from the keyboard. (Part 1 of 2.)

```
13
14          Console.Write( "Enter first integer: " ); // prompt user
15          // read first number from user
16          number1 = Convert.ToInt32( Console.ReadLine() );
17
18          Console.Write( "Enter second integer: " ); // prompt user
19          // read second number from user
20          number2 = Convert.ToInt32( Console.ReadLine() );
21
22          sum = number1 + number2; // add numbers
23
24          Console.WriteLine( "Sum is {0}", sum ); // display sum
25       } // end Main
26    } // end class Addition
```

```
Enter first integer: 45
Enter second integer: 72
Sum is 117
```

Fig. 3.14 | Displaying the sum of two numbers input from the keyboard. (Part 2 of 2.)

Comments
Lines 1–2

```
// Fig. 3.14: Addition.cs
// Displaying the sum of two numbers input from the keyboard.
```

state the figure number, file name and purpose of the app.

Class `Addition`
Line 5

```
public class Addition
```

begins the declaration of class `Addition`. Remember that the body of each class declaration starts with an opening left brace (line 6) and ends with a closing right brace (line 26).

Function `Main`
The app begins execution with `Main` (lines 8–25). The left brace (line 9) marks the beginning of `Main`'s body, and the corresponding right brace (line 25) marks the end of `Main`'s body. Method `Main` is indented one level within the body of class `Addition` and the code in the body of `Main` is indented another level for readability.

Declaring Variable `number1`
Line 10

```
int number1; // declare first number to add
```

is a **variable declaration statement** that specifies the name (`number1`) and type of a variable (`int`) used in this app. Variables are typically declared with a **name** and a **type** before they're used. A variable's name can be any valid identifier. A variable's type specifies what kind of information is stored at that location in memory and how much space should be set aside to store that value. Like other statements, declaration statements end with a semicolon (`;`).

Type `int`

The declaration in line 10 specifies that the variable named `number1` is of type **`int`**—it will hold **integer** values (whole numbers such as `7`, `-11`, `0` and `31914`). The range of values for an `int` is –2,147,483,648 (`int.MinValue`) to +2,147,483,647 (`int.MaxValue`). We'll soon discuss types **`float`**, **`double`** and **`decimal`**, for specifying real numbers, and type **`char`**, for specifying characters. Real numbers contain decimal points, as in `3.4`, `0.0` and `-11.19`. Variables of type `float` and `double` store approximations of real numbers in memory. Variables of type `decimal` store real numbers precisely (to 28–29 significant digits), so `decimal` variables are often used with *monetary calculations*. Variables of type `char` represent individual characters, such as an uppercase letter (e.g., `A`), a digit (e.g., `7`), a special character (e.g., `*` or `%`) or an escape sequence (e.g., the newline character, `\n`). Types such as `int`, `float`, `double`, `decimal` and `char` are often called **simple types**. Simple-type names are keywords and must appear in all lowercase letters. Appendix B summarizes the characteristics of the simple types (`bool`, `byte`, `sbyte`, `char`, `short`, `ushort`, `int`, `uint`, `long`, `ulong`, `float`, `double` and `decimal`).

Declaring Variables `number2` *and* `sum`

The variable declaration statements at lines 11–12

```
int number2; // declare second number to add
int sum; // declare sum of number1 and number2
```

similarly declare variables `number2` and `sum` to be of type `int`.

Variable declaration statements can be split over several lines, with the variable names separated by commas (i.e., a comma-separated list of variable names). Several variables of the same type may be declared in one declaration or in multiple declarations. For example, lines 10–12 can also be written as follows:

```
int number1, // declare first number to add
    number2, // declare second number to add
    sum; // declare sum of number1 and number2
```

Good Programming Practice 3.5

Declare each variable on a separate line. This format allows a comment to be easily inserted next to each declaration.

Good Programming Practice 3.6

By convention, variable-name identifiers begin with a lowercase letter, and every word in the name after the first word begins with a capital letter. This naming convention is known as ***lower camel casing****.*

Prompting the User for Input

Line 14

```
Console.Write( "Enter first integer: " ); // prompt user
```

uses `Console.Write` to display the message `"Enter first integer: "`. This message is called a **prompt** because it directs the user to take a specific action.

Reading a Value into Variable **`number1`**

Line 16

```
    number1 = Convert.ToInt32( Console.ReadLine() );
```

works in two steps. First, it calls the `Console`'s **`ReadLine`** method, which waits for the user to type a string of characters at the keyboard and press the *Enter* key. As we mentioned, some methods perform a task then return the result of that task. In this case, `ReadLine` returns the text the user entered. Then, the `string` is used as an argument to class **`Convert`**'s **`ToInt32`** method, which converts this sequence of characters into data of type `int`. In this case, method `ToInt32` returns the `int` representation of the user's input.

Possible Erroneous User Input

Technically, the user can type anything as the input value. `ReadLine` will accept it and pass it off to the `ToInt32` method. This method assumes that the string contains a valid integer value. In this app, if the user types a noninteger value, a runtime logic error called an exception will occur and the app will terminate. C# offers a technology called *exception handling* that will help you make your apps more robust by enabling them to handle exceptions and continue executing. We introduce exception handling in Section 8.4, then use it again in Chapter 10. We take a deeper look at exception handling in Chapter 13.

Assigning a Value to a Variable

In line 16, the result of the call to method `ToInt32` (an `int` value) is placed in variable `number1` by using the **assignment operator**, `=`. The statement is read as "`number1` gets the value returned by `Convert.ToInt32`." Operator `=` is a **binary operator**, because it works on two pieces of information. These are known as its **operands**—in this case, the operands are `number1` and the result of the method call `Convert.ToInt32`. Everything to the right of the assignment operator, `=`, is always evaluated *before* the assignment is performed.

Good Programming Practice 3.7

Place spaces on either side of a binary operator to make the code more readable.

Prompting the User for Input and Reading a Value into Variable **`number2`**

Line 18

```
    Console.Write( "Enter second integer: " ); // prompt user
```

prompts the user to enter the second integer. Line 20

```
    number2 = Convert.ToInt32( Console.ReadLine() );
```

reads a second integer and assigns it to the variable `number2`.

Summing the **`number1`** *and* **`number2`**

Line 22

```
    sum = number1 + number2; // add numbers
```

calculates the sum of `number1` and `number2` and assigns the result to variable `sum` by using the assignment operator, `=`. The statement is read as "`sum` gets the value of `number1 + number2`." Most calculations are performed in assignment statements. When `number1 + number2` is encountered, the values stored in the variables are used in the calculation. The addition operator is a binary operator—its two **operands** are `number1` and `number2`. Portions of statements that contain calculations are called **expressions**. In fact, an expression is any portion of a statement that has a value associated with it. For example, the value of the expression `number1 + number2` is the sum of the numbers. Similarly, the value of the expression `Console.ReadLine()` is the string of characters typed by the user.

Displaying the `sum`

After the calculation has been performed, line 24

```
      Console.WriteLine( "Sum is {0}", sum ); // display sum
```

uses method `Console.WriteLine` to display the `sum`. The format item `{0}` is a placeholder for the first argument after the format string. Other than the `{0}` format item, the remaining characters in the format string are all *fixed* text. So method `WriteLine` displays `"Sum is "`, followed by the value of `sum` (in the position of the `{0}` format item) and a newline.

Performing Calculations in Output Statements

Calculations can also be performed inside output statements. We could have combined the statements in lines 22 and 24 into the statement

```
      Console.WriteLine( "Sum is {0}", ( number1 + number2 ) );
```

The parentheses around the expression `number1 + number2` are not required—they're included for clarity to emphasize that the value of the expression `number1 + number2` is output in the position of the `{0}` format item.

3.7 Arithmetic

Most apps perform arithmetic calculations. The **arithmetic operators** are summarized in Fig. 3.15. Note the various special symbols not used in algebra. The **asterisk** (`*`) indicates multiplication, and the **percent sign** (**%**) is the **remainder operator** (called *modulus* in some languages), which we'll discuss shortly. The arithmetic operators in Fig. 3.15 are binary operators—for example, the expression `f + 7` contains the binary operator `+` and the two operands `f` and `7`.

C# operation	Arithmetic operator	Algebraic expression	C# expression
Addition	`+`	$f + 7$	`f + 7`
Subtraction	`–`	$p - c$	`p - c`
Multiplication	`*`	$b \cdot m$	`b * m`
Division	`/`	x / y or $\frac{x}{y}$ or $x \div y$	`x / y`
Remainder	`%`	$r \bmod s$	`r % s`

Fig. 3.15 | Arithmetic operators.

If both operands of the division operator (`/`) are integers, **integer division** is performed and the result is an integer—for example, the expression `7 / 4` evaluates to `1`, and the expression `17 / 5` evaluates to `3`. Any fractional part in integer division is simply *truncated* (i.e., discarded)—*no rounding* occurs. C# provides the remainder operator, `%`, which yields the remainder after division. The expression `x % y` yields the remainder after `x` is divided by `y`. Thus, `7 % 4` yields `3`, and `17 % 5` yields `2`. This operator is most commonly used with integer operands but can also be used with `float`s, `double`s, and `decimal`s.

Arithmetic Expressions in Straight-Line Form

Arithmetic expressions must be written in **straight-line form** to facilitate entering apps into the computer. Thus, expressions such as "`a` divided by `b`" must be written as `a / b`, so that all constants, variables and operators appear in a straight line. The following algebraic notation is not acceptable to compilers:

$$\frac{a}{b}$$

Parentheses for Grouping Subexpressions

Parentheses are used to group terms in C# expressions in the same manner as in algebraic expressions. For example, to multiply `a` times the quantity `b + c`, we write

```
a * ( b + c )
```

If an expression contains **nested parentheses**, such as

```
( ( a + b ) * c )
```

the expression in the *innermost* set of parentheses (`a + b` in this case) is evaluated first.

Rules of Operator Precedence

C# applies the operators in arithmetic expressions in a precise sequence determined by the following **rules of operator precedence**, which are generally the same as those followed in algebra (Fig. 3.16). These rules enable C# to apply operators in the correct order.[2]

Operators	Operations	Order of evaluation (associativity)
Evaluated first		
`*`	Multiplication	If there are several operators of this type,
`/`	Division	they're evaluated from left to right.
`%`	Remainder	
Evaluated next		
`+`	Addition	If there are several operators of this type,
`-`	Subtraction	they're evaluated from left to right.

Fig. 3.16 | Precedence of arithmetic operators.

2. We discuss simple examples here to explain the order of evaluation of expressions. More subtle order of evaluation issues occur in complex expressions. For more information, see the following blog posts from Eric Lippert: `blogs.msdn.com/ericlippert/archive/2008/05/23/precedence-vs-associativity-vs-order.aspx` and `blogs.msdn.com/oldnewthing/archive/2007/08/14/4374222.aspx`.

When we say that operators are applied from left to right, we're referring to their **associativity**. You'll see that some operators associate from right to left. Figure 3.16 summarizes these rules of operator precedence. The table will be expanded as additional operators are introduced. Appendix A provides the complete operator precedence chart.

3.8 Decision Making: Equality and Relational Operators

A **condition** is an expression that can be either **true** or **false**. This section introduces a simple version of C#'s **`if` statement** that allows an app to make a **decision** based on the value of a condition. For example, the condition "grade is greater than or equal to 60" determines whether a student passed a test. If the condition in an `if` statement is true, the body of the `if` statement executes. If the condition is false, the body does *not* execute. We'll see an example shortly.

Conditions in `if` statements can be formed by using the **equality operators** (**==** and **!=**) and **relational operators** (**>**, **<**, **>=** and **<=**) summarized in Fig. 3.17. The two equality operators (== and !=) each have the same level of precedence, the relational operators (>, <, >= and <=) each have the same level of precedence, and the equality operators have lower precedence than the relational operators. They all associate from left to right.

Common Programming Error 3.5

Confusing the equality operator, ==, with the assignment operator, =, can cause a logic error or a syntax error. The equality operator should be read as "is equal to," and the assignment operator should be read as "gets" or "gets the value of." To avoid confusion, some programmers read the equality operator as "double equals" or "equals equals."

Standard algebraic equality and relational operators	C# equality or relational operator	Sample C# condition	Meaning of C# condition
Relational operators			
>	`>`	`x > y`	`x` is greater than `y`
<	`<`	`x < y`	`x` is less than `y`
≥	`>=`	`x >= y`	`x` is greater than or equal to `y`
≤	`<=`	`x <= y`	`x` is less than or equal to `y`
Equality operators			
=	`==`	`x == y`	`x` is equal to `y`
≠	`!=`	`x != y`	`x` is not equal to `y`

Fig. 3.17 | Relational and equality operators.

Using the `if` Statement

Figure 3.18 uses six `if` statements to compare two integers entered by the user. If the condition in any of these `if` statements is true, the assignment statement associated with that `if` statement executes. The app uses class `Console` to prompt for and read two lines of text from the user, extracts the integers from that text with the `ToInt32` method of class `Con-`

vert, and stores them in variables number1 and number2. Then the app compares the numbers and displays the results of the comparisons that are true.

```
// Fig. 3.18: Comparison.cs
// Comparing integers using if statements, equality operators
// and relational operators.
using System;

public class Comparison
{
    // Main method begins execution of C# app
    public static void Main( string[] args )
    {
        int number1; // declare first number to compare
        int number2; // declare second number to compare

        // prompt user and read first number
        Console.Write( "Enter first integer: " );
        number1 = Convert.ToInt32( Console.ReadLine() );

        // prompt user and read second number
        Console.Write( "Enter second integer: " );
        number2 = Convert.ToInt32( Console.ReadLine() );

        if ( number1 == number2 )
            Console.WriteLine( "{0} == {1}", number1, number2 );

        if ( number1 != number2 )
            Console.WriteLine( "{0} != {1}", number1, number2 );

        if ( number1 < number2 )
            Console.WriteLine( "{0} < {1}", number1, number2 );

        if ( number1 > number2 )
            Console.WriteLine( "{0} > {1}", number1, number2 );

        if ( number1 <= number2 )
            Console.WriteLine( "{0} <= {1}", number1, number2 );

        if ( number1 >= number2 )
            Console.WriteLine( "{0} >= {1}", number1, number2 );
    } // end Main
} // end class Comparison
```

```
Enter first integer: 42
Enter second integer: 42
42 == 42
42 <= 42
42 >= 42
```

Fig. 3.18 | Comparing integers using if statements, equality operators and relational operators. (Part 1 of 2.)

```
Enter first integer: 1000
Enter second integer: 2000
1000 != 2000
1000 < 2000
1000 <= 2000
```

```
Enter first integer: 2000
Enter second integer: 1000
2000 != 1000
2000 > 1000
2000 >= 1000
```

Fig. 3.18 | Comparing integers using `if` statements, equality operators and relational operators. (Part 2 of 2.)

Class `Comparison`

The declaration of class `Comparison` begins at line 6

```
      public class Comparison
```

The class's `Main` method (lines 9–39) begins the execution of the app.

Variable Declarations

Lines 11–12

```
      int number1; // declare first number to compare
      int number2; // declare second number to compare
```

declare the `int` variables used to store the values entered by the user.

Reading the Inputs from the User

Lines 14–16

```
      // prompt user and read first number
      Console.Write( "Enter first integer: " );
      number1 = Convert.ToInt32( Console.ReadLine() );
```

prompt the user to enter the first integer and input the value. The input value is stored in variable `number1`. Lines 18–20

```
      // prompt user and read second number
      Console.Write( "Enter second integer: " );
      number2 = Convert.ToInt32( Console.ReadLine() );
```

perform the same task, except that the input value is stored in variable `number2`.

Comparing Numbers

Lines 22–23

```
      if ( number1 == number2 )
         Console.WriteLine( "{0} == {1}", number1, number2 );
```

compare the values of the variables `number1` and `number2` to determine whether they're equal. An `if` statement always begins with keyword `if`, followed by a condition in parentheses. An `if` statement expects *one* statement in its body. Line 23 executes only if the numbers stored in variables `number1` and `number2` are equal (i.e., the condition is true). The `if` statements in lines 25–26, 28–29, 31–32, 34–35 and 37–38 compare `number1` and `number2` with the operators `!=`, `<`, `>`, `<=` and `>=`, respectively. If the condition in any of the `if` statements is true, the corresponding body statement executes.

No Semicolon at the End of the First Line of an `if` *Statement*

There's no semicolon (`;`) at the end of the first line of each `if` statement. Such a semicolon would result in a logic error at execution time. For example,

```
if ( number1 == number2 ); // logic error
   Console.WriteLine( "{0} == {1}", number1, number2 );
```

would actually be interpreted by C# as

```
if ( number1 == number2 )
   ; // empty statement

Console.WriteLine( "{0} == {1}", number1, number2 );
```

where the semicolon in the line by itself—called the **empty statement**—is the statement to execute if the condition in the `if` statement is true. When the empty statement executes, no task is performed in the app. The app then continues with the output statement, which always executes, regardless of whether the condition is true or false, because the output statement is not part of the `if` statement.

Whitespace

Note the use of whitespace in Fig. 3.18. Recall that whitespace characters, such as tabs, newlines and spaces, are normally ignored by the compiler. So statements may be split over several lines and may be spaced according to your preferences without affecting the meaning of an app. It's incorrect to split identifiers, strings, and multicharacter operators (like `>=`). Ideally, statements should be kept small, but this is not always possible.

Good Programming Practice 3.8

Place no more than one statement per line in an app. This format enhances readability.

Good Programming Practice 3.9

A lengthy statement can be spread over several lines. If a single statement must be split across lines, choose breaking points that make sense, such as after a comma in a comma-separated list, or after an operator in a lengthy expression. If a statement is split across two or more lines, indent all subsequent lines until the end of the statement.

Precedence and Associativity of the Operators We've Discussed So Far

Figure 3.19 shows the precedence of the operators introduced in this chapter. The operators are shown from top to bottom in decreasing order of precedence. All these operators, with the exception of the assignment operator, `=`, associate from left to right. Addition is left associative, so an expression like `x + y + z` is evaluated as if it had been written as `(x + y) + z`. The assignment operator, `=`, associates from right to left, so an expression like `x = y = 0` is evaluated as if it had been written as `x = (y = 0)`, which, as you'll soon see, first assigns the value `0` to variable `y` then assigns the result of that assignment, `0`, to `x`.

Operators	Associativity	Type
`*` `/` `%`	left to right	multiplicative
`+` `-`	left to right	additive
`<` `<=` `>` `>=`	left to right	relational
`==` `!=`	left to right	equality
`=`	right to left	assignment

Fig. 3.19 | Precedence and associativity of operations discussed so far.

3.9 Wrap-Up

You learned many important features of C# in this chapter. First you learned how to display data on the screen in a **Command Prompt** using the `Console` class's `Write` and `WriteLine` methods. Next, we showed how to use format strings and format items to create formatted output strings. You learned how to input data from the keyboard using the `Console` class's `ReadLine` method. We discussed how to perform calculations using C#'s arithmetic operators. Finally, you made decisions using the `if` statement and the relational and equality operators. As you'll see in Chapter 4, C# apps typically contain just a few lines of code in method `Main`—these statements normally create the objects that perform the work of the app. You'll implement your own classes and use objects of those classes in apps.

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