// Step by step
Microsoft Visual C++/CLI

Intermediate

Julian Templeman
Microsoft Visual C++/CLI
Step by Step

Julian Templeman
I would like to dedicate this book to my wife, Jane, without whose steadfast love and support none of this would be possible.

—Julian Templeman
# Contents at a Glance

*Introduction*  

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Introduction

C++ is a powerful, industrial-strength programming language used in tens of thousands of applications around the world, and this book will show you how to get started using C++ on Windows.

Of all the languages supported by Microsoft, C++ gives you access to the widest range of technologies on the Windows platform, from writing games, through low-level system software, to line-of-business applications. This book is going to introduce you to several of the areas in which C++ is used in Windows development.

For over a decade .NET has become established as the way to write desktop applications for Windows, and it provides a wealth of technologies to support developers. C++/CLI is the variant of C++ that runs in the .NET environment, and you can use it, along with other languages such as C#, to create rich desktop applications.

More recently, Windows 8 has introduced many new features to the Windows operating system, but perhaps the most exciting is the debut of Windows Store applications. These graphical applications are designed to run on touch screen and mobile devices, and provide a completely new way to construct user interfaces on Windows. C++ is one of the main languages supported for Windows Store development, and this book will give you an introduction to these applications and how to develop them in C++/CX, another variant of C++ introduced specifically for this purpose.

Who should read this book

This book exists to help programmers learn how to write applications using C++ on the Windows platform. It will be useful to those who want an introduction to writing .NET applications using C++, as well as to those who want to see how to write Windows Store applications.

If you are specifically interested in Windows Store applications, you may wish to look at Build Windows 8 Apps with Microsoft Visual C++ Step by Step by Luca Regnicoli, Paolo Pialorsi, and Roberto Brunetti, published by Microsoft Press.
Assumptions
This book expects that you have some experience of programming in a high-level language, so that you are familiar with concepts such as functions and arrays. It is quite sufficient to have experience in a procedural language such as Visual Basic, and I do not assume that you have any experience of object-oriented programming in general, or of C++ in particular (although any knowledge of a “curly bracket” language will be useful).

Who should not read this book
This book is not suitable for complete beginners to programming. For readers who are completely new to programming and want to learn C++, I recommend starting with a book such as Programming: Principles and Practice Using C++ by Bjarne Stroustrup, published by Addison-Wesley.

This book is also not suitable for those who want to learn standard C++ or older-style Win32 development, because it concentrates on two Microsoft variants (C++/CLI and C++/CX) and does not cover topics such as the CLR or MFC in any detail.

Organization of this book
This book is divided into four sections.

- Part I, “Getting Started,” introduces the main parts of the C++ language, getting you used to coding in C++ and building applications in Visual Studio 2012.
- Part II, “Microsoft .NET Programming Basics,” continues by introducing those parts of C++ that are specific to Microsoft’s C++/CLI language.
- Part III, “Using the .NET Framework,” covers the main features in the .NET Framework libraries used for writing .NET applications. This part includes discussion of working with files, XML and databases, and creating graphical applications.
- Part IV, “Advanced Topics,” covers some more advanced material, including details for working with legacy code.
Finding your best starting point in this book

The various sections of this book cover a wide range of technologies associated with C++ on the Windows platform. Depending on your needs and your existing understanding of C++, you may wish to focus on specific areas of the book. Use the following table to determine how best to proceed through the book.

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<th>If you are</th>
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<td>New to C++</td>
<td>Read Part I carefully before continuing to the rest of</td>
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<td>the book.</td>
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<tr>
<td>Familiar with OO programming but not with C++</td>
<td>Read Part I carefully, but you can omit Chapter 2.</td>
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<tr>
<td>Familiar with C++</td>
<td>Review Part I, looking for the differences between</td>
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<td>standard C++ and C++/CLI.</td>
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<tr>
<td>Familiar with .NET, but not Windows Store</td>
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Most of the book’s chapters include exercises that let you try out the concepts you have just learned. Solutions to these exercises can be downloaded using the companion code link from this book’s web page. See the “Code samples” section for details on how to download the companion code.

Conventions and features in this book

This book presents information using conventions designed to make the information readable and easy to follow.

- Each exercise consists of a series of tasks, presented as numbered steps (1, 2, and so on) listing each action you must take to complete the exercise.

- Boxed elements with labels such as “Note” provide additional information or alternative methods for completing a step successfully.

- Text that you type (apart from code blocks) appears in bold.

- A plus sign (+) between two key names means that you must press those keys at the same time. For example, “Press Alt+Tab” means that you hold down the Alt key while you press the Tab key.

- A vertical bar between two or more menu items (e.g., File | Close) means that you should select the first menu or menu item, then the next, and so on.
System requirements

You will need the following hardware and software to complete the practice exercises in this book:

- One of Windows 7, Windows 8, Windows Server 2008 with Service Pack 2, or Windows Server 2008 R2. Note that if you want to build and run the Windows Store applications featured in Chapters 20 and 21, you will need Windows 8.
- Visual Studio 2012, any edition
- A computer that has a 1.6 GHz or faster processor (2 GHz is recommended)
- 1 GB (32 Bit) or 2 GB (64 Bit) RAM
- 3.5 GB of available hard disk space
- 5400 RPM hard disk drive
- DirectX 9 capable video card running at 1024 x 768 or higher-resolution display
- DVD-ROM drive (if installing Visual Studio from DVD)
- Internet connection to download software or chapter examples

Depending on your Windows configuration, you might require Local Administrator rights to install or configure Visual Studio 2012.

Code samples

Most of the chapters in this book include exercises that let you interactively try out new material learned in the main text. All sample projects, in both their pre-exercise and post-exercise formats, can be downloaded from the following page:

http://aka.ms/VCCLISbS/files
Acknowledgments

Producing a book involves a number of people, and I’d like to thank the following in particular.

I’d like to thank all at Microsoft Press and O’Reilly for their help and support, especially Devon Musgrave at Microsoft for inviting me to start this project, and Russell Jones at O’Reilly for providing so much help with writing and editorial matters, and especially his guidance in using the (not always good-tempered) Word templates.

The technical quality of the book has been greatly improved by Luca Regnicoli, who as tech reviewer pointed out numerous errors and omissions. I especially value his input on the Windows Store chapters.

Kara Ebrahim at O’Reilly, along with Dianne Russell and Bob Russell at Octal Publishing, provided excellent editorial support and made sure everything got done on time.

And lastly, I’d like to thank my family, who have put up with all the extra work involved in writing a book, and are probably hoping that this is last one for a while!

Errata and book support

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CHAPTER 1

Hello C++!

After completing this chapter, you will be able to

- Recognize C++ functions.
- Recognize C++ keywords and identifiers.
- Create a C++ application.

Welcome to the exciting world of programming Microsoft .NET with Microsoft Visual C++. This chapter introduces the C++/CLI language and shows you how to perform simple input/output (I/O).

What is C++/CLI?

C++/CLI is a version of the C++ programming language designed to run on the .NET Framework. It has been available since Microsoft Visual Studio 2005 and is the subject of an international standard. You can find details of the ECMA standard at http://www.ecma-international.org/publications/standards/Ecma-372.htm.

To achieve this, some changes had to be made to standard C++. There are some things that you can do in standard C++ that are not permitted in C++/CLI (for example, you cannot inherit from multiple base classes) and there have been some changes to the language geared to support .NET features (such as interfaces and properties) and to work with the .NET Runtime.

Why would you choose to use C++/CLI to write .NET code instead of another .NET language such as C#? Apart from personal preference, there are two very good reasons to choose C++/CLI. The first is for interoperability; C++/CLI makes it simple to incorporate standard C++ code into .NET projects. The second is that we have a .NET version of the C++ Standard Template Library (STL), and so people used to coding against the STL will find it possible to work in the same way in .NET.

Even if neither of these reasons applies to you, C++/CLI is still a perfectly good way to learn about .NET programming because it exposes all of the features that you need to write .NET programs and explore the .NET platform.
Your first C++/CLI application

It’s time to get our hands dirty with a simple C++/CLI application. Of course, no programming book would be complete without including the customary "Hello World" application, so let’s start with that.

```c++
using namespace System;

int main()
{
    Console::WriteLine("Hello, World!");
    return 0;
}
```

This short application illustrates some fundamental C++/CLI concepts:

- The first line (which begins with `using`) informs the compiler that you’re using the .NET System library. Many different libraries could be used in a single project; the using statement specifies to the compiler which library you want to use.

- The rest of the application is an example of a C++ function. All blocks of code in C++ are called functions—there’s no such thing as a procedure or a subroutine. Each C++ function contains the header (the first line of this application) and the function body (all of the text between the braces, { and }). The header shows the return type of the function (in this case `int`, short for integer), the name of the function (`main`), and the list of parameters inside round brackets. Note that you still need to include the round brackets even if you don’t have anything to pass to the function.

- All statements in C++ are terminated with a semicolon.

Of the six lines of code in the example application, only two contain C++ statements: the `Console` line and the `return` line. The `Console` line outputs characters to the console, and the argument to the function consists of the string that you want to output. The `return` line exits from the function—in this case, the application, because there is only one function—and returns zero, which is the standard value to return when execution is successful.

The `main` function

Why is the only function in the previous example called `main`? The simple answer is that the code won’t compile if it isn’t! However, it might be more useful to explain how the language works.

A normal C++ application contains many functions (and also many classes, as is discussed in Chapter 2, “Introducing object-oriented programming”). How does the compiler know which function should be called first? Obviously, you can’t allow the compiler to just randomly choose a function. The rule is that the compiler always generates code that looks for a function named `main`. If you omit the `main` function, the compiler reports an error and doesn’t create a finished executable application.
Free-format languages

C++ falls under the category of a free-format language, which means that the compiler ignores all spaces, carriage returns, new-line characters, tabs, form feeds, and so on. Collectively, these characters are referred to as white space. The only time the compiler recognizes white space is if it occurs within a string.

Free-format languages give the programmer great scope for using tab or space indenting as a way of organizing application layout. Statements inside a block of code—such as a for loop or an if statement—are typically indented (often by four space characters). This indentation helps the programmer’s eye more easily pick out the contents of the block.

The free-format nature of C++ gives rise to one of the most common (and least useful) arguments in the C++ community: how do you indent the braces? Should they be indented with the code, or should they be left hanging at the beginning of the if or for statement? There is no right or wrong answer to this question (although some hardened C++ developers might disagree), but a consistent use of either style helps to make your application more readable to humans. As far as the compiler is concerned, your entire application could be written on one line.

So, the compiler will expect a function named main. Is that all there is to it? Well, not quite. There are some additional items, such as the return type and parameters being correct, but in the case of main, some of the C++ rules are relaxed. In particular, main can take parameters that represent the command-line arguments, but you can omit them if you don’t want to use the command line.

C++ keywords and identifiers

A C++ keyword (also called a reserved word) is a word that means something to the compiler. The keywords used in the example application are using, namespace, and return. You’re not allowed to use these keywords as variable or function names; the compiler will report an error if you do. You’ll find that Visual Studio helps you identify keywords by displaying them in a special color.

An identifier is any name that the programmer uses to represent variables and functions. An identifier must start with a letter and must contain only letters, numbers, or underscores. The following are legal C++ identifiers:

- My_variable
- AReallyLongName

The following are not legal C++ identifiers:

<table>
<thead>
<tr>
<th>Invalid identifier</th>
<th>Reason for being invalid</th>
</tr>
</thead>
<tbody>
<tr>
<td>0800Number</td>
<td>Must not start with a number</td>
</tr>
<tr>
<td>You+Me</td>
<td>Must contain only letters, numbers, and underscores (the plus sign is the culprit here)</td>
</tr>
<tr>
<td>return</td>
<td>Must not be a reserved word</td>
</tr>
</tbody>
</table>
Outside of these restrictions, any identifier will work. However, some choices are not recommended, such as the following:

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Reason it’s not recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>main</td>
<td>Could be confused with the function main.</td>
</tr>
<tr>
<td>INT</td>
<td>Too close to the reserved word int.</td>
</tr>
<tr>
<td>B4ugotxtme</td>
<td>Just too cryptic!</td>
</tr>
<tr>
<td>_identifier1</td>
<td>Underscores at the beginning of names are allowed, but they are not recommended because</td>
</tr>
<tr>
<td></td>
<td>compilers often use leading underscores when creating internal variable names, and they are</td>
</tr>
<tr>
<td></td>
<td>also used for variables in system code. To avoid potential naming conflicts, you should not use</td>
</tr>
<tr>
<td></td>
<td>leading underscores.</td>
</tr>
</tbody>
</table>

**Creating an executable application—theory**

Several stages are required to build an executable application; Microsoft Visual Studio 2012 helps you accomplish this by automating them. To examine and understand these stages, however, let’s look at them briefly. You’ll see these stages again later in the chapter when we build our first application.

**Editing the application source files**

Before you can create an application, you must write something. Visual Studio 2012 provides an integrated C++ editor, complete with color syntax highlighting and Microsoft IntelliSense to show function parameter information and provide word completion.

**Compiling the source files**

The C++/CLI compiler is the tool for converting text source files into something that can be executed by a computer processor. The compiler takes your source files (which usually have a .cpp extension) and builds them into either a stand-alone executable file (with a .exe extension) or a library file to be used in other projects (with a .dll extension).

**Standard C++ and C**

If you have ever worked with standard C++ or C, you might be familiar with the idea of compiling to object files and then linking with libraries to build the final executable file—which is commonly referred to simply as an executable. Although you can compile to the equivalent of an object file (called a module in the .NET world) and then link those together by using a tool called the assembly linker, Visual Studio takes you straight from source to executable without you seeing the intermediate step.
Running and testing the application

After you have successfully built the application, you need to run it and test it.

For many development environments, running and testing is often the most difficult part of the application development cycle. However, Visual Studio 2012 has yet another ace up its sleeve: the integrated debugger. The debugger has a rich set of features with which you can easily perform runtime debugging, such as setting breakpoints and variable watches.

Creating an executable application—practice

Go ahead and start Visual Studio 2012. An invitingly blank window appears on your screen.

This window is the powerful Visual Studio integrated development environment (IDE). It contains all the tools you’ll need to create full-featured, easy-to-use applications.

Note This book was written by using the Release Candidate (RC) version of Visual Studio 2012. As a result, screen shots and other details might differ from the version you’re using when you read this.
Creating a project
The first task is to create a new project for the “Hello, World” program.

1. In Visual Studio, on the File menu, point to New, and then click Project. (Alternatively, you can press Ctrl+Shift+N.)

Note I am using the Professional version of Visual Studio 2012. If you are using other versions, the way in which you create a project might be different. For example, in the Express version, you will find New Project on the File menu.

The New Project dialog box opens.

2. In the navigation pane on the left, under Templates, click Visual C++, and then click CLR. In the center pane, click CLR Console Application and then, toward the bottom of the dialog box, in the Name box, type **HelloWorld**.

Note Depending on how Visual Studio has been set up, you might find Visual C++ under the Other Languages node.

3. Click the Location list and select a location for your new project or click Browse and navigate to an appropriate directory.
Click OK to create the project.

The wizard correctly initializes all the compiler settings for a console project.

**Editing the C++ source code**

The wizard creates a project for you with all the files needed for a simple console application. It also opens the main source file in the editor that contains just the code we want.

Notice that the keywords automatically appear in blue (provided that you spell them correctly).

There are a few things in the automatically generated source code that we don’t need, so let’s remove them. This will give you some practice in using the editor as well as making the code easier to understand. The application is not going to receive any command-line arguments when you run it, so remove everything between the opening and closing parentheses following `main`—in this example, `array<System::String ^> ^args`. In addition, the “L” before the “Hello World” string isn’t necessary either (for reasons that I’ll explain later), so you can remove that, as well.

**Building the executable**

The next step is to build the executable. The term *build* in Visual Studio 2012 refers to compiling and linking the application. Visual Studio compiles any source files that have changed since the last build and—if no compile errors were generated—performs a link.

To build the executable, on the Build menu, click Build Solution or press F7.
**Note** The shortcut keys might differ depending on the version of Visual Studio you are using. For example, in the Ultimate edition, the shortcut is F6.

An Output window opens near the bottom of the Visual Studio window, showing the build progress. If no errors are encountered, the message *Build: 1 succeeded, 0 failed, 0 up-to-date, 0 skipped* will appear in the Output window. If this window is closed, you can open it by selecting Output from the View menu.

If any problems occur, the Error List window will contain a list of errors and warnings.

You can double-click the error line in the Error List window to place the cursor at the line in the source file where the compiler encountered the error. Fix the error (you might have misspelled a keyword or forgotten a semicolon) and rebuild the project. If the Error List pane is closed, you can open it by selecting Error List from the View menu.

**How should you treat warnings?**
Always treat warnings as errors—in other words, get rid of them. Warnings are there for a reason; they’re telling you that your code is not correct.
Executing the application

After you’ve eliminated all errors and you’ve successfully built the project, you can finally execute the application. On the Debug menu, click Start Without Debugging to run the application. You can also press Ctrl+F5 to execute the application.

You’ll see the output of your application, with the message “Press any key to continue” at the bottom of the output. This line is added by the IDE so that the console window doesn’t simply disappear when the application has finished running.

Conclusion

Although the example in this chapter isn’t the most exciting application ever written, it demonstrates some key C++ development points. It introduces the Visual Studio 2012 IDE and the ability to compile and link a application, and it serves as an introduction to the C++/CLI language.

Now, there’s no turning back. Every new C++/CLI and Visual Studio 2012 feature that you learn about will fire your imagination to learn more and be increasingly productive. Software development is an exciting world.

Finally, don’t forget to have some fun. Go back and try a few variations on the example application, click a few menus, and take some time to become familiar with the environment.

Quick reference

<table>
<thead>
<tr>
<th>To</th>
<th>Do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create a new project in Visual Studio 2012.</td>
<td>Click File</td>
</tr>
<tr>
<td>Add a file to a project.</td>
<td>Click File</td>
</tr>
<tr>
<td>Build a Visual Studio 2012 project.</td>
<td>Click Build</td>
</tr>
<tr>
<td>Execute a program from within Visual Studio 2012.</td>
<td>Click Debug</td>
</tr>
</tbody>
</table>
CHAPTER 5

Decision and loop statements

After completing this chapter, you will be able to:

■ Make decisions by using the if statement.
■ Make multiway decisions by using the switch statement.
■ Perform loops by using the while, for, and do-while statements.
■ Perform unconditional jumps in a loop by using the break and continue statements.

All high-level languages provide keywords with which you can make decisions and perform loops. C++ is no exception. C++ provides the if statement and the switch statement for making decisions, and it provides the while, for, and do-while statements for performing loops. In addition, C++ provides the break statement to exit a loop immediately and the continue statement to return to the start of the loop for the next iteration.

In this chapter, you will see how to use these statements to control the flow of execution through a C++/CLI application.

Making decisions by using the if statement

The most common way to make a decision in C++/CLI is to use the if statement. You can use the if statement to perform a one-way test, a two-way test, a multiway test, or a nested test. Let’s consider a simple one-way test first.

Performing one-way tests

The following example shows how to define a one-way test in C++/CLI:

```csharp
if (number < 0)
    Console::WriteLine("The number is negative");
Console::WriteLine("The end");
```

The if keyword is followed by a conditional expression, which must be enclosed in parentheses. If the conditional expression evaluates to true, the next statement is executed, which in this example will display the message “The number is negative”. Notice that the message “The end” will always be displayed, regardless of the outcome of the test, because it is outside the body of the if statement.
Note There is no semicolon after the closing parenthesis in the if test. It is a common C++ programming error to put one in by mistake, as shown here:

\[
\text{if (number < 0); // Note the spurious semicolon}
\]

This statement is equivalent to the following statement, which is probably not what you intended:

\[
\text{if (number < 0) ; // Null if-body – do nothing if number < 0}
\]

If you want to include more than one statement in the if body, enclose the if body in braces ({}), as follows:

\[
\text{if (number < 0)}
\begin{align*}
\text{& \{ Console::Write("The number ");} \\
\text{& Console::Write(number);} \\
\text{& Console::WriteLine(" is negative");} \\
\text{& Console::WriteLine("The end");}
\end{align*}
\]

Many developers reckon that it is good practice to enclose the if body in braces, even if it only consists of a single statement. This means that the code will still be correct if you (or another developer) add more statements to the if body in the future.

In this exercise, you will create a new application to perform one-way tests. As this chapter progresses, you will extend the application to use more complex decision-making constructs and to perform loops. For now, the application asks the user to enter a date and then it performs simple validation and displays the date in a user-friendly format on the console.

1. Start Visual Studio 2012 and create a new CLR Console Application project. Name the application CalendarAssistant.

2. At the top of the source code file, immediately below the using namespace System; line, add the following function prototypes (you will implement all these functions during this chapter):

\[
\begin{align*}
\text{int GetYear();} \\
\text{int GetMonth();} \\
\text{int GetDay(int year, int month);} \\
\text{void DisplayDate(int year, int month, int day);} \\
\end{align*}
\]

3. At the end of the file, after the end of the main function, implement the GetYear function as follows:

\[
\text{int GetYear()}
\begin{align*}
\text{& } \\
\text{& \{ Console::Write("Year? ");} \\
\text{& String ^input = Console::ReadLine();} \\
\text{& int year = Convert::ToInt32(input);} \\
\text{& return year;}
\end{align*}
\]
4. Implement the `GetMonth` function as follows:

```csharp
int GetMonth()
{
    Console::Write("Month?");
    String ^input = Console::ReadLine();
    int month = Convert::ToInt32(input);
    return month;
}
```

This is a simplified implementation; later in this chapter, you will enhance the function to ensure that the user enters a valid month.

5. Implement the `GetDay` function as follows:

```csharp
int GetDay(int year, int month)
{
    Console::Write("Day?");
    String ^input = Console::ReadLine();
    int day = Convert::ToInt32(input);
    return day;
}
```

Later, you will enhance this function to ensure that the user enters a valid day for the given year and month.

6. Implement the `DisplayDate` function as shown in the following code to display the date as three numbers:

```csharp
void DisplayDate(int year, int month, int day)
{
    Console::WriteLine("This is the date you entered:");
    Console::Write(year);
    Console::Write("-");
    Console::Write(month);
    Console::Write("-");
    Console::Write(day);
    Console::WriteLine();
}
```

Later in this chapter you will enhance this function to display the date in a more user-friendly format.

7. Add the following code inside the `main` method, immediately before the `return 0;` line:

```csharp
Console::WriteLine("Welcome to your calendar assistant");
Console::WriteLine("Please enter a date");
int year = GetYear();
int month = GetMonth();
int day = GetDay(year, month);
```
// Simplified test for now – assume there are 31 days in
// every month :-) 
if (month >= 1 && month <= 12 && day >= 1 && day <= 31)
{
   DisplayDate(year, month, day);
}
Console::WriteLine("\nThe end\n");

This code asks the user to enter a year, month, and day. If the date passes a simplified validation test, the date is displayed on the console. If the date is invalid, it is not displayed at all.

**Note** This if statement combines several tests by using the logical AND operator &&. As you learned in Chapter 3, “Variables and operators,” logical tests are performed from left to right. Testing stops as soon as the final outcome has been established. For example, if the month is 0, there is no point performing the other tests—the date is definitely invalid. This is known as *short-circuit evaluation*.

8. Build the application and fix any compiler errors that you might have.

9. Run the application. Type in valid numbers for the year, month, and day (for example, 2012, 7, and 22).

The application displays the messages shown in the following screen shot:

```
Welcome to your calendar assistant
Please enter a date
Year? 2012
Month? 7
Day? 22
This is the date you entered:
2012-7-22
The End
Press any key to continue . . .
```

Observe that the application displays the date because it is valid. The message “The End” also appears at the end of the program.

10. Run the application again, but this time, type an invalid date (for example, 2012, 2, and 33). The application displays the messages shown in the following screen shot:
Notice that because the date you typed was invalid, the application doesn’t display it. Instead, it just displays “The End.” You can make the application more user-friendly by displaying an error message if the date is invalid. To do so, you need to use a two-way test.

Performing two-way tests

The following code shows how to define a two-way test for the Calendar Assistant application:

```csharp
if (month >= 1 && month <= 12 && day >= 1 && day <= 31)
{
    DisplayDate(year, month, day);
} else
{
    Console::WriteLine("Invalid date");
}
Console::WriteLine("\nThe end\n");
```

The else body defines what action to perform if the test condition fails.

In this exercise, you will enhance your Calendar Assistant application to display an error message if an invalid date is entered.

1. Continue working with the project from the previous exercise.
2. Modify the main function, replacing the simple if with an if-else statement to test for valid or invalid dates.

```csharp
if (month >= 1 && month <= 12 && day >= 1 && day <= 31)
{
    DisplayDate(year, month, day);
} else
{
    Console::WriteLine("Invalid date");
}
Console::WriteLine("\nThe end\n");
```
3. Build and run the application. Type an invalid date such as 2001, 0, and 31.

The application now displays an error message, as demonstrated in the following screen shot:

![Screen shot of error message](image)

**Performing multiway tests**

You can arrange *if-else* statements in a cascading fashion to perform multiway decision making.

The following code shows how to use a multiway test to determine the maximum number of days (*maxDay*) in a month:

```cpp
int maxDay;
if (month == 4 || month == 6 || month == 9 || month == 11)
{
    maxDay = 30;
}
else if (month == 2)
{
    maxDay = 28;
}
else
{
    maxDay = 31;
}
```

This code specifies that if the month is April, June, September, or November, set *maxDay* to 30. If the month is February, *maxDay* is set to 28. (We’ll ignore leap years for now!) If the month is anything else, set *maxDay* to 31.

**Note** There is a space between the keywords *else* and *if* because they are distinct keywords. This is unlike Microsoft Visual Basic.NET, which uses the single keyword *Elseif*.

In this exercise, you will enhance your Calendar Assistant application to display the maximum number of days in the user’s chosen month.
1. Continue working with the project from the previous exercise.

2. Replace the *GetDay* function with the following code so that it uses an *if-else-if* statement to determine the maximum allowable number of days.

   ```c++
   int GetDay(int year, int month)
   {
      int maxDay;
      if (month == 4 || month == 6 || month == 9 || month == 11)
      {
         maxDay = 30;
      }
      else if (month == 2)
      {
         maxDay = 28;
      }
      else
      {
         maxDay = 31;
      }
      Console::Write("Day [1 to ");
      Console::Write(maxDay);
      Console::Write(")? ");
      String ^input = Console::ReadLine();
      int day = Convert::ToInt32(input);
      return day;
   }
   ```

3. Build and run the application. Type the year 2012 and the month 1.

   The application prompts you to enter a day between 1 and 31, as illustrated in the following screen shot:

4. Type a valid day and close the console window when the date is displayed.
5. Run the application again. Type the year **2012** and the month **2**.

The application prompts you to enter a day between 1 and 28, as shown here:

![Application screenshot](image)

6. Type a valid day and close the console window when the date is displayed. (Don’t worry about the date validation in *main*: You will remove it later and replace it with more comprehensive validation in the *GetMonth* and *GetDay* functions.)

### Performing nested tests

It is possible to nest tests within one another. This makes it possible for you to perform more complex logical operations. The following code shows how to use nested tests to accommodate leap years correctly in the Calendar Assistant application:

```cpp
int maxDay;
if (month == 4 || month == 6 || month == 9 || month == 11)
{
    maxDay = 30;
}
else if (month == 2)
{
    bool isLeapYear = (year % 4 == 0 && year % 100 != 0) || (year % 400 == 0);
    if (isLeapYear)
    {
        maxDay = 29;
    }
    else
    {
        maxDay = 28;
    }
}
else
{
    maxDay = 31;
}
```

If the month is February, you define a `bool` variable to determine if the year is a leap year. A year is a leap year if it is evenly divisible by 4 but not evenly divisible by 100 (except years that are evenly divisible by 400, which are leap years). The following table shows some examples of leap years and non–leap years.
### Making decisions by using the `switch` Statement

Now that you have seen how the *if* statement works, let's take a look at the *switch* statement. Using the *switch* statement, you can test a single variable and execute one of several branches depending on the variable’s value.

#### Defining simple *switch* statements

The example that follows shows the syntax for the *switch* statement. The *switch* statement tests the `numberOfSides` in a shape and displays a message to describe that shape.

<table>
<thead>
<tr>
<th>Year</th>
<th>Leap year?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>Yes</td>
</tr>
<tr>
<td>1997</td>
<td>No</td>
</tr>
<tr>
<td>1900</td>
<td>No</td>
</tr>
<tr>
<td>2000</td>
<td>Yes</td>
</tr>
</tbody>
</table>

You then use a nested *if* statement to test the *bool* variable `isLeapYear` so that you can assign an appropriate value to `maxDay`.

**Note** There is no explicit test in the nested *if* statement. The condition `if (isLeapYear)` is equivalent to `if (isLeapYear != false)`.

In this exercise, you will enhance your Calendar Assistant application to deal correctly with leap years.

1. Continue working with the project from the previous exercise.
2. Modify the *GetDay* function, replacing the `if...else if...else` statements to match the block of code just described to test for leap years.
3. Build and run the application. Type the year **1996** and the month **2**. The application prompts you to enter a day between 1 and 29. Type a valid day and then when the date is displayed, close the console window.
4. Run the application again. Type the year **1997** and the month **2**. Verify that the application prompts you to enter a day between 1 and 28.
5. Run the application several more times using the test data from the previous table.
int numberOfSides;  // Number of sides in a shape
...
switch (numberOfSides)
{
    case 3:  Console::Write("Triangle");    break;
    case 4:  Console::Write("Quadrilateral"); break;
    case 5:  Console::Write("Pentagon");    break;
    case 6:  Console::Write("Hexagon");     break;
    case 7:  Console::Write("Septagon");    break;
    case 8:  Console::Write("Octagon");    break;
    case 9:  Console::Write("Nonagon");    break;
    case 10: Console::Write("Decagon");    break;
    default: Console::Write("Polygon");    break;
}

The switch keyword is followed by an expression in parentheses. This expression must evaluate to
an integer, a character, or an enumeration value. The body of the switch consists of a series of case
branches, each of which comprises the keyword case, a value, and a colon.

The value identifying a case branch must be a constant of integer type. This means that integer
numbers, enumeration values, and characters are allowed. For example, 5 and a are valid, but abc is
not because it is a string literal.

**Note** Each case label specifies a single literal value. You can’t specify multiple values, you
can’t define a range of values, and the values must be known at compile time. This means
that you can’t, for instance, say case foo, where foo is a variable whose value will only be
known when the application executes.

Each case branch can contain any number of statements. At the end of each branch, use a break
statement to exit the switch statement.

**Note** There is normally no need to use braces around the code in a case branch. The break
statement marks the end of each case branch. However, you do need to use braces if you
need to declare a variable within the branch code.

You can define an optional default branch in the switch statement. The default branch will be ex-
ecuted if the expression doesn’t match any of the case labels.

**Tip** It’s good practice to define a default branch even if you don’t have any specific pro-
cessing to perform. Including the default branch shows that you haven’t just forgotten it.
Also, the default branch can help you trap unexpected values and display a suitable warn-
ing to the user.

In this exercise, you will enhance your Calendar Assistant application to display the month as a
string such as January or February.
1. Continue working with the project from the previous exercise.

2. Modify the `DisplayDate` function. Rather than display the month as an integer, replace the `Console::Write(month)` statement with a `switch` statement that displays the month as a string.

switch (month)
{
    case 1:  Console::Write("January");   break;
    case 2:  Console::Write("February");  break;
    case 3:  Console::Write("March");     break;
    case 4:  Console::Write("April");     break;
    case 5:  Console::Write("May");       break;
    case 6:  Console::Write("June");      break;
    case 7:  Console::Write("July");      break;
    case 8:  Console::Write("August");    break;
    case 9:  Console::Write("September"); break;
    case 10: Console::Write("October");   break;
    case 11: Console::Write("November");  break;
    case 12: Console::Write("December");  break;
    default: Console::Write("Unknown");   break;
}

3. Build the application.

4. Run the application several times, typing a different month each time. Verify that the application displays the correct month name each time.

Using fall-through in a `switch` statement

If you omit the `break` statement at the end of a case branch, flow of control continues on to the next statement. This process is called *fall-through*. This can be useful to avoid duplication of code, but be careful not to do it accidentally.

The following example illustrates why fall-through might be useful. This example tests a lowercase letter to see if it is a vowel or a consonant:

```c++
char lowercaseLetter;   // Single lowercase letter, for example 'a'
...
switch (lowercaseLetter)
{
    case 'a':
    case 'e':
    case 'i':
    case 'o':
    case 'u':  Console::Write("Vowel"); break;
    default:   Console::Write("Consonant"); break;
}
```

There is no `break` statement in the first four case labels. As a result, the flow of control passes on to the next executable statement to display the message *Vowel*. The `default` branch deals with all the other letters and displays the message *Consonant*. 
In this exercise, you will enhance your Calendar Assistant application to display the season for the user's date.

1. Continue working with the project from the previous exercise.

2. Modify the DisplayDate function. After displaying the year, month, and day, add the following code after the line Console::Write(day) to display the season:

   ```c++
   switch (month)
   {
   case 12:
   case 1:
   case 2:  Console::WriteLine(" [Winter]"); break;
   case 3:
   case 4:
   case 5:  Console::WriteLine(" [Spring]"); break;
   case 6:
   case 7:
   case 8:  Console::WriteLine(" [Summer]"); break;
   case 9:
   case 10:
   case 11: Console::WriteLine(" [Fall]"); break;
   }
   ```

3. Build the application.

4. Run the application several times, typing a different month each time. Verify that the application displays the correct season name each time.

---

**Performing loops**

For the rest of this chapter, you’ll see how to perform loops in C++/CLI. You’ll also see how to perform unconditional jumps in a loop by using the `break` and `continue` statements.

C++ has three main loop constructs: the `while` loop, the `for` loop, and the `do-while` loop.

**Note** There is actually a fourth loop type, the `for-each` loop, but I’ll leave discussing that until we get to arrays.

Let’s look at the `while` loop first.

**Using `while` loops**

A `while` loop continues executing its body for as long as the condition in parentheses evaluates to true. The following example shows how to write a simple `while` loop in C++/CLI:
```csharp
int count = 1;
while (count <= 5)
{
    Console::WriteLine(count * count);  
    count++;
}
Console::WriteLine("The end");

You must follow the `while` keyword with a conditional expression enclosed in parentheses. As long as the conditional expression evaluates to true, the `while` body executes. After the loop body has been executed, control returns to the `while` statement and the conditional expression is tested again. This sequence continues until the test evaluates to false.

You must, of course, remember to include some kind of update statement in the loop so that it will terminate eventually. In this example `count++` is incrementing the loop counter. If you don’t provide an update statement, the loop will iterate forever, which probably isn’t what you want.

The preceding example displays the following output:

```
1
2
3
4
5
The end
```

In this exercise, you will enhance your Calendar Assistant application so that the user can type five dates.

1. Continue working with the project from the previous exercise.
2. Modify the code in the `main` function by replacing the entire body of the function with the following code:

```csharp
Console::WriteLine("Welcome to your calendar assistant");

int count = 1;  // Declare and initialize the loop counter
while (count <= 5)  // Test the loop counter
{
    Console::Write("Please enter a date 
");
    Console::WriteLine(count);
    int year = GetYear();
    int month = GetMonth();
    int day = GetDay(year, month);
    DisplayDate(year, month, day);
    count++;  // Increment the loop counter
}
3. Build and run the application. The application prompts you to enter the first date. After you have typed this date, the application prompts you to enter the second date. This process continues until you have typed five dates, at which point the application closes, as depicted in the following screen shot:

![Screen Shot](image)

**Using for loops**

The *for* loop is an alternative to the *while* loop. It provides more control over the way in which the loop executes.

The following example shows how to write a simple *for* loop in C++/CLI. This example has exactly the same effect as the *while* loop.

```c++
for (int count = 1; count <= 5; count++)
{
    Console::WriteLine(count * count);
}

Console::WriteLine("The end");
```

The parentheses after the *for* keyword contain three expressions separated by semicolons. The first expression performs loop initialization, such as initializing the loop counter. This initialization expression is executed once only, at the start of the loop.

The second expression statement defines a test. If the test evaluates to *true*, the loop body is executed, but if it is *false*, the loop finishes and control passes to the statement that follows the closing parenthesis. After the loop body has been executed, the final expression in the *for* statement is executed; this expression performs loop update operations, such as incrementing the loop counter.

**Note** You can declare loop variables in the first expression of the *for* statement. The preceding example illustrates this technique. The count variable is local to the *for* statement and goes out of scope when the loop terminates.

The second expression statement defines a test. If the test evaluates to *true*, the loop body is executed, but if it is *false*, the loop finishes and control passes to the statement that follows the closing parenthesis. After the loop body has been executed, the final expression in the *for* statement is executed; this expression performs loop update operations, such as incrementing the loop counter.
Note The for statement is very flexible. You can omit any of the three expressions in the for construct as long as you retain the semicolon separators. You can even omit all three expressions, as in for(;;), which represents an infinite loop.

The preceding example displays the output shown in the following screen shot.

In this exercise, you will modify your Calendar Assistant application so that it uses a for loop rather than a while loop to obtain five dates from the user.

1. Continue working with the project from the previous exercise.
2. Modify the code in the main function to use a for loop rather than a while loop, as shown here:

   ```csharp
   Console::WriteLine("Welcome to your calendar assistant");
   for (int count = 1; count <= 5; count++)
   {
     Console::Write("
Please enter date ");
     Console::WriteLine(count);
     int year = GetYear();
     int month = GetMonth();
     int day = GetDay(year, month);
     DisplayDate(year, month, day);
   }
   ```

   Notice that there is no count++ statement after displaying the date. This is because the for statement takes care of incrementing the loop counter.

3. Build and run the application. The application asks you to enter five dates, as before.

Using do-while loops

The third loop construct you’ll look at here is the do-while loop (remember, there’s still the for-each loop, which you will meet later). The do-while loop is fundamentally different from the while and for loops because the test comes at the end of the loop body, which means that the loop body is always executed at least once.
The following example shows how to write a simple do-while loop in C++/CLI. This example generates random numbers between 1 and 6, inclusive, to simulate a die. It then counts how many throws are needed to get a 6.

```csharp
Random ^r = gcnew Random();
int randomNumber;
int throws = 0;
do
{
    randomNumber = r->Next(1, 7);
    Console::WriteLine(randomNumber);
    throws++;
} while (randomNumber != 6);

Console::Write("You took ");
Console::Write(throws);
Console::WriteLine(" tries to get a 6");
```

The loop starts with the do keyword, followed by the loop body, followed by the while keyword and the test condition. A semicolon is required after the closing parenthesis of the test condition.

The preceding example displays the output shown in the following screen shot:

![Screen shot of output](image)

In this exercise, you will modify your Calendar Assistant application so that it performs input validation, which is a typical use of the do-while loop.

1. Continue working with the project from the previous exercise.
2. Modify the GetMonth function as follows, which forces the user to type a valid month:

```csharp
int GetMonth()
{
    int month = 0;
do
    {
        Console::Write("Month [1 to 12]? ");
        String ^input = Console::ReadLine();
        month = Convert::ToInt32(input);
    } while (month < 1 || month > 12);
    return month;
}
```
while (month < 1 || month > 12);
return month;
}

3. Modify the GetDay function as follows, which forces the user to type a valid day:

```
int GetDay(int year, int month)
{
    int day = 0;
    int maxDay;

    // Calculate maxDay, as before (code not shown here) ...

    do
    {   
        Console::Write("Day [1 to ");
        Console::Write(maxDay);
        Console::Write("] ? ");
        String ^input = Console::ReadLine();
        day = Convert::ToInt32(input);
    } while (day < 1 || day > maxDay);
    return day;
}
```

4. Build and run the application.

5. Try to type an invalid month. The application keeps asking you to enter another month until you type a value between 1 and 12, inclusive.

6. Try to type an invalid day. The application keeps asking you to enter another day until you type a valid number (which depends on your chosen year and month).

**Performing unconditional jumps**

C++/CLI provides two keywords—`break` and `continue`—with which you can jump unconditionally within a loop. The `break` statement causes you to exit the loop immediately. The `continue` statement abandons the current iteration and goes back to the top of the loop ready for the next iteration.

*Note* The `break` and `continue` statements can make it difficult to understand the logical flow through a loop. Use `break` and `continue` sparingly to avoid complicating your code unnecessarily.

In this exercise, you will modify the main loop in your Calendar Assistant application. You will give the user the chance to break from the loop prematurely, skip the current date and continue on to the next one, or display the current date as normal.

1. Continue working with the project from the previous exercise.
2. Modify the main function as follows, which gives the user the option to break or continue if desired:

```csharp
Console::WriteLine("Welcome to your calendar assistant");
for (int count = 1; count <= 5; count++)
{
    Console::Write("Please enter date ");
    Console::WriteLine(count);
    int year = GetYear();
    int month = GetMonth();
    int day = GetDay(year, month);

    Console::Write("Press B (break), C (continue), or ");
    Console::Write("anything else to display date ");
    String ^input = Console::ReadLine();
    if (input->Equals("B"))
    {
        break;
    }
    else if (input->Equals("C"))
    {
        continue;
    }
    DisplayDate(year, month, day);
}
```

Note The Equals method is used here to check that two strings contain the same content. You will see another (and more idiomatic) way to do this using the == operator when we discuss operator overloading.

3. Build and run the application.

4. After you type the first date, you are asked whether you want to break or continue. Press X (or any other key except B or C) and then press Enter to display the date as normal.

5. Type the second date, and then press C followed by Enter, which causes the continue statement to be executed.

   The continue statement abandons the current iteration without displaying your date. Instead, you are asked to type the third date.

6. Type the third date and then press B, which causes the break statement to be executed. The break statement terminates the entire loop.
### Quick reference

<table>
<thead>
<tr>
<th>To</th>
<th>Do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform a one-way test.</td>
<td>Use the <em>if</em> keyword followed by a test enclosed in parentheses. You must enclose the <em>if</em> body in braces if it contains more than one statement. For example:</td>
</tr>
<tr>
<td></td>
<td>if ( n &lt; 0 )</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>Console::Write(&quot;The number &quot;);</td>
</tr>
<tr>
<td></td>
<td>Console::Write(n);</td>
</tr>
<tr>
<td></td>
<td>Console::WriteLine(&quot; is negative&quot;);</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
<tr>
<td>Perform a two-way test.</td>
<td>Use an <em>if-else</em> construct. For example:</td>
</tr>
<tr>
<td></td>
<td>if ( n &lt; 0 )</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>Console::Write(&quot;Negative&quot;);</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
<tr>
<td></td>
<td>else</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>Console::Write(&quot;Not negative&quot;);</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
<tr>
<td>Perform a multiway test.</td>
<td>Use an <em>if-else-if</em> construct. For example:</td>
</tr>
<tr>
<td></td>
<td>if ( n &lt; 0 )</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>Console::Write(&quot;Negative&quot;);</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
<tr>
<td></td>
<td>else if ( n == 0 )</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>Console::Write(&quot;Zero&quot;);</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
<tr>
<td></td>
<td>else</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>Console::Write(&quot;Positive&quot;);</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
<tr>
<td>Test a single expression against a finite set of constant values.</td>
<td>Use the <em>switch</em> keyword followed by an integral expression enclosed in parentheses. Define case branches for each value you want to test against, and define a default branch for all other values. Use the <em>break</em> statement to close a branch. For example:</td>
</tr>
<tr>
<td></td>
<td>int dayNumber; // 0=Sun, 1=Mon, etc.</td>
</tr>
<tr>
<td></td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>switch (dayNumber)</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>case 0:</td>
</tr>
<tr>
<td></td>
<td>case 6:</td>
</tr>
<tr>
<td></td>
<td>Console::Write(&quot;Weekend&quot;);</td>
</tr>
<tr>
<td></td>
<td>break;</td>
</tr>
<tr>
<td></td>
<td>default:</td>
</tr>
<tr>
<td></td>
<td>Console::Write(&quot;Weekday&quot;);</td>
</tr>
<tr>
<td></td>
<td>break;</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
<tr>
<td>Perform iteration by using the <em>while</em> loop.</td>
<td>Use the <em>while</em> keyword followed by a test enclosed in parentheses. For example:</td>
</tr>
<tr>
<td></td>
<td>int ( n = 10 );</td>
</tr>
<tr>
<td></td>
<td>while ( (n &gt;= 0) )</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>Console::WriteLine(n);</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>n--;</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
<tr>
<td><strong>To</strong></td>
<td><strong>Do this</strong></td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Perform iteration by using the <em>for</em> loop.</td>
<td>Use the <em>for</em> keyword followed by a pair of parentheses. Within the parentheses, define an initialization expression, followed by a test expression, followed by an update expression. Use semicolons to separate these expressions. For example:</td>
</tr>
<tr>
<td></td>
<td>```</td>
</tr>
<tr>
<td></td>
<td>for (int n = 10; n &gt;= 0; n--)</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>Console::WriteLine(n);</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
<tr>
<td></td>
<td>```</td>
</tr>
<tr>
<td>Perform iteration by using the <em>do-while</em> loop.</td>
<td>Use the <em>do</em> keyword, followed by the loop body, followed by the <em>while</em> keyword and the test condition. Terminate the loop with a semicolon. For example:</td>
</tr>
<tr>
<td></td>
<td>```</td>
</tr>
<tr>
<td></td>
<td>int n;</td>
</tr>
<tr>
<td></td>
<td>do</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>String^ input = Console::ReadLine();</td>
</tr>
<tr>
<td></td>
<td>n = Convert::ToInt32(input);</td>
</tr>
<tr>
<td></td>
<td>} while (n &gt; 100);</td>
</tr>
<tr>
<td></td>
<td>```</td>
</tr>
<tr>
<td>Terminate a loop prematurely.</td>
<td>Use the <em>break</em> statement inside any loop. For example:</td>
</tr>
<tr>
<td></td>
<td>```</td>
</tr>
<tr>
<td></td>
<td>for (int n = 0; n &lt; 1000; n++)</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>int square = n * n;</td>
</tr>
<tr>
<td></td>
<td>if (square &gt; 3500)</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>break;</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
<tr>
<td></td>
<td>Console::WriteLine(square);</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
<tr>
<td>Abandon a loop iteration and continue with the next iteration.</td>
<td>Use the <em>continue</em> statement inside any loop. For example:</td>
</tr>
<tr>
<td></td>
<td>```</td>
</tr>
<tr>
<td></td>
<td>for (int n = 0; n &lt; 1000; n++)</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>int square = n * n;</td>
</tr>
<tr>
<td></td>
<td>if (square % 2 == 0)</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>continue;</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
<tr>
<td></td>
<td>Console::WriteLine(square);</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
</tbody>
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About the author

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