



CHAPTER 6

C#

FILES AND STREAMS

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Introduction

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- Variables and arrays offer only temporary storage of data: the data is lost when a local variable "goes out of scope" or when the program terminates.
 - By contrast, files (and databases) are used for long-term retention of large amounts of data, even after the program that created the data terminates.
 - Data maintained in files often is called **persistent data**.
- Computers store files on secondary storage devices, such as magnetic disks, optical disks, flash memory and magnetic tapes.

- Most applications require data to be stored in files
 - Spreadsheets
 - Word processing
 - etc
- C# has an extensive set of classes for handling files of various types
 - These are to be found in the **System.IO namespace**
- The general concept of streams will be applied to both files and networks

- In C#, streams are simply sequences of bytes
 - No formatting structure is placed on this byte stream, this is imposed by the application
 - We can read a byte stream from an *input stream* object
 - We can write a byte stream to an *output stream* object
 - The input and output stream objects are created from class ***FileStream***

Data Hierarchy

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- Ultimately, all data items that computers process are reduced to combinations of 0s and 1s.
 - This occurs because it's simple and economical to build electronic devices that can assume two stable states one state represents 0 and the other represents 1.
- It's remarkable that the impressive functions performed by computers involve only the most fundamental manipulations of 0s and 1s.

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□ Bits

- The smallest data item that computers support is called a bit (short for “binary digit”—a digit that can assume one of two values).

□ Characters

- It's preferable to program with data in forms such as decimals digits, letters and special symbols and many others. These referred to as **characters**.

□ Fields

- It is a group of characters that conveys meaning.

□ **Records**

- Record is composed of several related fields.

□ **Files**

- File is a group of related records
- **Record key**
 - To facilitate the retrieval of specific records from a file, at least one field in each record is chosen as a record key, which identifies a record as belonging to a particular person or entity and distinguishes that record from all others.
- **Sequential Files**
 - A common organization of records in a file, a sequential file, in which records typically are stored in order by a record-key field

- **Database**

- Related data are often stored in a **database**. A collection of programs designed to create and manage databases is called a **database management system (DBMS)**.

Files and Streams

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- C# views each file as a **sequential stream of bytes**.
 - Each file ends either with an **end-of-file marker** or at a specific byte number that's recorded in a system maintained administrative data structure.
 - When a file is opened, an object is created and a stream is associated with the object.
 - When a console app executes, the runtime environment creates three stream objects that are accessible via properties **Console.Out**, **Console.In** and **Console.Error**, respectively.

What is Stream?

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- A stream is an **ordered sequence of bytes**, which is send from one application or input device to another application or output device.
 - These bytes are written and read one after the other and always arrive in the same order as they were sent.
 - Streams are an **abstraction of a data communication channel that connects two devices or applications**.
- Every time when you read or write from or to a file, you have to **open a stream** to the corresponding file, do the reading or writing, and then **close the stream**.

- There are two types of streams – **text streams** and **binary streams** but this separation has to do with the interpretation of the sent and received bytes.
 - Sometimes, for convenience, a sequence of bytes can be treated as text (in a predefined encoding) and is referred to as a text stream.
- Streams allow **sequential data access** (manipulate the data only in the order in which it arrives from the stream).

□ Basic operations with Streams

- **Creation**
 - Connect the stream to a data source, a mechanism for data transfer or another stream.
- **Reading**
 - Extracting data from the stream.
- **Writing**
 - Sending data to the stream in a specific way
- **Positioning**
 - Move the current position of the stream.
- **Closing**
 - Complete the work with the stream and releases the occupied resources
 - Always **close the streams and files you work with!**

Streams in .NET – Basic Classes

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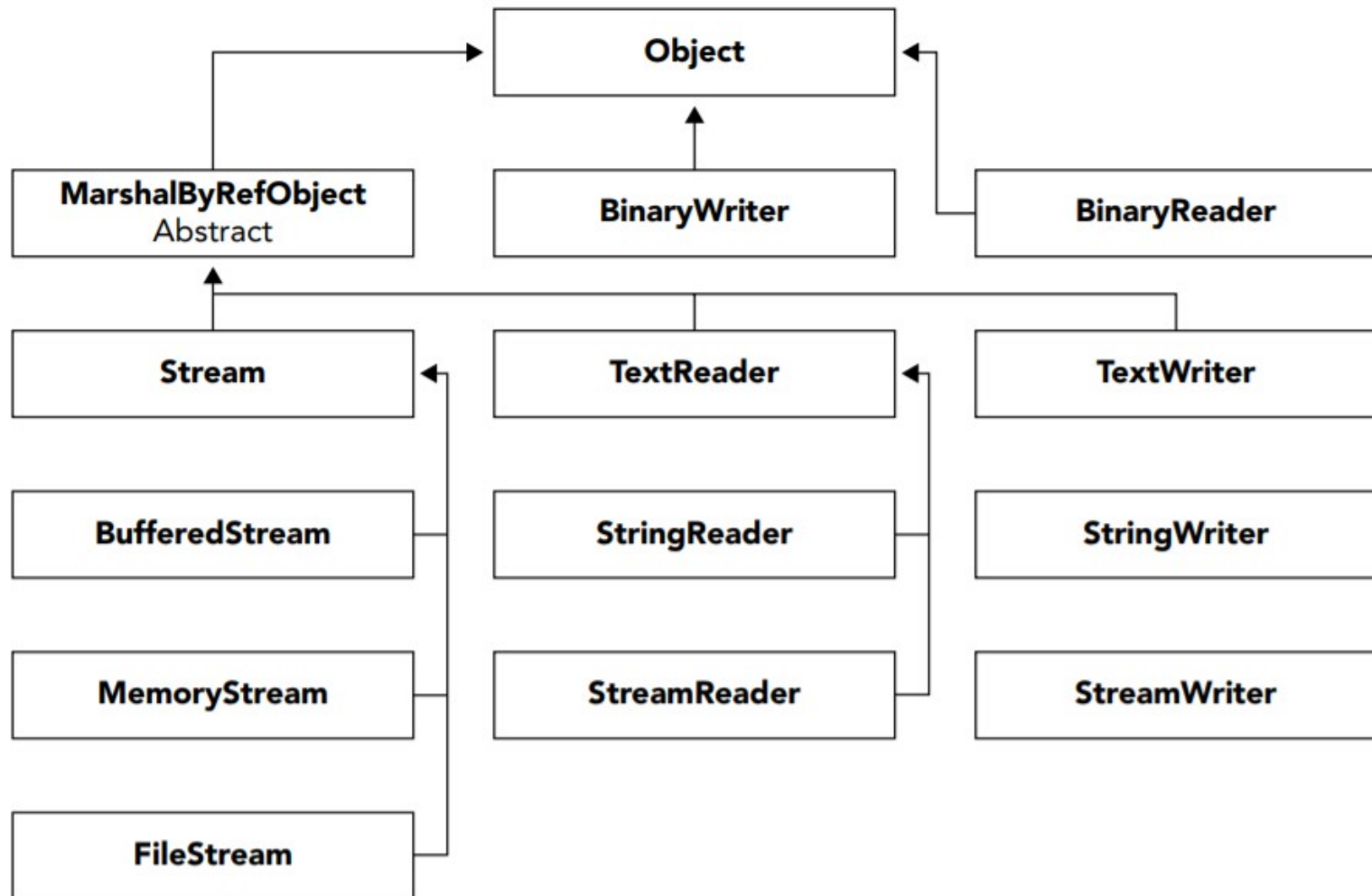
- In .NET Framework classes for working with streams are located in the namespace **System.IO**.
 - We can distinguish two main types of streams – those who work with **binary data** and those who work with **text data**.
 - **Binary Stream**
 - **FileStream**, **BinaryReader** and **BinaryWriter**.
 - **Text Stream**
 - **TextReader** and **TextWriter**.
 - **StreamReader** and **StreamWriter**

□ Binary Stream

- The main classes that we use to read and write from and to binary streams are:
 - **FileStream:** provides us with various methods for reading and writing from a binary file.
 - **BinaryReader:** enables you to write primitive types and binary values in a specific encoding to a stream.
 - **BinaryWriter:** allows you to read primitive data types and binary values recorded using a BinaryWriter.

□ Text Streams

- The main classes for working with text streams in .NET are **TextReader** and **TextWriter**.
- The classes **StreamReader** and **StreamWriter** directly inherit the **TextReader** and **TextWriter** classes and implement functionality for reading and writing textual information to and from a file.
- To create an object of type **StreamReader** or **StreamWriter**, we need a file or a string, containing the file path.
 - Working with these classes, we can use all of the methods that we are already familiar with, to work with the console.



Classes File and Directory

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- Information is stored in **files**, which are organized in **directories** (also called folders).
 - Classes File and Directory enable programs to **manipulate files and directories on disk**.
 - **Class File** can **determine information about files** and can be used to **open files** for **reading** or **writing**.
 - **Class Directory** provides capabilities for **manipulating directories**.
 - Each class contains a large set of **static methods** for both manipulation and

Static methods of File

Static Method	Description
AppendText	Returns a StreamWriter that appends text to an existing file or creates a file if one does not exist.
Copy	Copies a file to a new file.
Create	Creates a file and returns its associated FileStream.
CreateText	Creates a text file and returns its associated StreamWriter.
Delete	Deletes the specified file.
Exists	Returns true if the specified file exists and false otherwise.
GetCreationTime	Returns a DateTime object representing when the file was created.
GetLastAccessTime	Returns a DateTime object representing when the file was last accessed.
GetLastWriteTime	Returns a DateTime object representing when the file was last modified.
Move	Moves the specified file to a specified location.
Open	Returns a FileStream associated with the specified file and equipped with the specified read/write permissions.
OpenRead	Returns a read-only FileStream associated with the specified file.
OpenText	Returns a StreamReader associated with the specified file.
OpenWrite	Returns a read/write FileStream associated with the specified file.

Static methods of Directory

Static method	Description
CreateDirectory	Creates a directory and returns its associated DirectoryInfo object.
Delete	Deletes the specified directory.
Exists	Returns true if the specified directory exists and false otherwise.
GetDirectories	Returns a string array containing the names of the subdirectories in the specified directory.
GetFiles	Returns a string array containing the names of the files in the specified directory.
GetCreationTime	Returns a DateTime object representing when the directory was created.
GetLastAccessTime	Returns a DateTime object representing when the directory was last accessed.
GetLastWriteTime	Returns a DateTime object representing when items were last written to the directory.
Move	Moves the specified directory to a specified location.

Reading/Writing a Sequential Access File (Text File)

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□ Reading to a Text File

□ Class for reading a Text file:

StreamReader

- The System.IO. StreamReader class provides the easiest way to read a text file, as it resembles reading from the console.

```
1 // Create a StreamReader connected to a file
  StreamReader reader = new StreamReader("test.txt");
  // Read the file here ...
  // Close the reader resource after you've finished using it
  reader.Close();
```

□ Full and Relative Paths

- When working with files we can use full paths (e.g. C:\Temp\example.txt) or relative paths, to the directory from which the application was started (e.g. ..\..\example.txt).
- Note that if the file is located in the folder where the compiled project (subdirectory **bin\Debug**) is, we can only provide its filename. Otherwise, we have to provide the full file path or relative path.

2. Reading a Text File Line by Line

- We use **ReadLine()** to read the line in the file.
- Other methods: **Read** and **ReadToEnd**

3. Closing the stream

- Once we have read everything we need from the file, we should not forget to close the object `StreamReader`, as to avoid loss of resources. For this, we use the method **Close()**.

□ Automatic Closing of the Stream after Working with It

- The correct way to handle the file closing is through the `using` keyword:

using () { ... }

- The C# construct `using(...)` ensures that after leaving its body, the method `Close()` will automatically be called. This will happen even if an exception occurs when

```
StreamReader reader = new StreamReader("Sample.txt");
using (reader)
{
    int lineNumber = 0;
    // Read first line from the text file
    string line = reader.ReadLine();
    // Read the other lines from the text file
    while (line != null)
    {
        lineNumber++;
        Console.WriteLine("Line {0}: {1}", lineNumber, line);
        line = reader.ReadLine();
    }
}
```

□ Writing to a Text File

□ Class for writing a Text file: **StreamWriter**

- The class StreamWriter is part of the System.IO namespace and is used exclusively for working with text data

1. **Open a Text File for writing**

- We can create an instance of the class the
`StreamWriter writer = new StreamWriter("test.txt");`

2. Writing a Text File Line by Line

- We use **WriteLine()** to write a line in the file.
- Other methods: **Write**
- Be sure to close the stream after you finish using it! The best way to dispose any unused resources is with the **using** construct in C#.

Example: File Writing

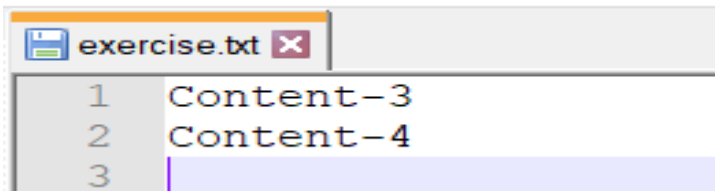
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```
/*
 *   Write the following text inside first.txt
 *
 *       My favorite programming languages are:
 *       1. C#
 *       2. Java
 *       3. C++
 */
string firstFileName = "first.txt";
using (StreamWriter output = new StreamWriter(firstFileName))
{
    // new text for the file
    output.WriteLine("My favorite programming languages are:");
    // append the following text
    output.WriteLine("1. C#");
    // append the following text
    output.WriteLine("2. Java");
    // append the following text
    output.WriteLine("3. C++");
}
```

Exercise: What is the content of the exercise.txt file?

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```
string exercise = "exercise.txt";
using (StreamWriter writer1 = new StreamWriter(exercise))
{
    // new text for the file
    writer1.WriteLine("Content-1");
    // append the following text
    writer1.WriteLine("Content-2");
}
using (StreamWriter writer2 = new StreamWriter(exercise,true))
{
    // new text for the file
    writer2.WriteLine("Content-3");
    // append the following text
    writer2.WriteLine("Content-4");
}
```



The screenshot shows a text editor window with the title 'exercise.txt'. The editor contains three lines of text: 'Content-3' on line 1, 'Content-4' on line 2, and a blank line on line 3. The lines are numbered 1, 2, and 3 on the left margin.

Line	Content
1	Content-3
2	Content-4
3	

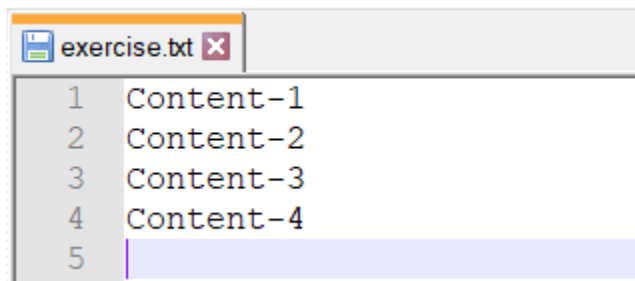
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StreamWriter: Appending Text with new writer object

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- To append the text for the next stream writer we will use the second parameter of the StreamWriter constructor

```
using (StreamWriter writer2 = new StreamWriter(exercise, true))
{
    // new text for the file
    writer2.WriteLine("Content-3");
    // append the following text
    writer2.WriteLine("Content-4");
}
```



```
exercise.txt x
1 Content-1
2 Content-2
3 Content-3
4 Content-4
5
```

□ **Input / Output Exception Handling**

- The most common exception when working with files is the **FileNotFoundException** (its name infers that the desired file was not found). It can occur when creating StreamReader.
- When setting a specified encoding by the creation of a StreamReader or a StreamWriter object, an **ArgumentException** can be thrown. This means, that the encoding we have chosen is not supported.
- Another common mistake is **IOException**. This is the base class for all IO errors when working with streams.

Exercise 1:

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- Catch exceptions that occur when working with files.
- 1. A text file words.txt is given, enroll the numbers from 1 to 20, each number on a separate line in the given file.
- 2. Write a program that reads a text file and prints its odd lines on the console.
- 3. Write a program that joins two text files and records the results in a third file.

Random Access Files

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- Sequential-access files are inappropriate for so-called “**instant-access**” applications, in which a particular record of information must be located immediately.
 - Popular instant-access applications include airline-reservation systems, banking systems, point-of-sale systems, automated-teller machines and other kinds of transaction-processing systems requiring **rapid access to specific data**.
- This type of instant access is made possible by **random-access files**.

Reading/Writing a Binary File

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- **System.IO.BinaryWriter** and **System.IO.BinaryReader** can be used for writing and reading primitive data types.
 - byte, short, int, long, float, double, bool, char and also the data type string and StringBuilder to a stream (binary file manipulation).
- Class **FileStream** provides methods for writing streams to files and inherits from class Stream, so we can **pass the FileStream object as an argument to the BinaryWriter** constructor.
 - We can use the BinaryWriter to write bytes directly to the file

□ Writing Binary File

```
FileStream fs = new FileStream("info.txt",  
                               FileMode.OpenCreate, FileAccess.Write);  
BinaryWriter bw = new BinaryWriter(fs);  
bw.Write(123);  
bw.Write(56.78);  
bw.Write('A');  
bw.Write(true);  
bw.Close();  
fs.Close();
```

□ Reading Binary File

```
FileStream fs = new FileStream("info.txt",  
                               FileMode.OpenCreate, FileAccess.Read);  
BinaryReader br = new BinaryReader(fs);  
int i = br.ReadInt32();  
double d = br.ReadDouble();  
char c = br.ReadChar();  
bool b = br.ReadBoolean();  
br.Close();  
fs.Close();
```

- FileStream objects support random access to files using the **FileStream.Seek** method.
 - The Seek method allows the read/write position to be moved to any position within the file.
 - This is done with byte offset reference point parameters.
 - The byte offset is relative to the seek reference point, which can be the **beginning**, the **current** position, or the **end** of the underlying file, as represented by the three properties of the **SeekOrigin** class.

Seek Method

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- The basic syntax for this method is:
Seek (value , SeekOrigin.Origin)
 - Where
 - **value** – is the point relative to Origin from which to begin seeking
 - **Origin** – specifies the position of the file pointer as a reference point for value, it could be three values: Begin, End and Current

Example

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```
//Open the file for reading purpose:
using (FileStream read = new FileStream(filename, FileMode.Open))
{
    Console.WriteLine("In Word " + name);
    int first = read.ReadByte();
    Console.WriteLine("The First Character is: \"{0}\" ", (char)first);

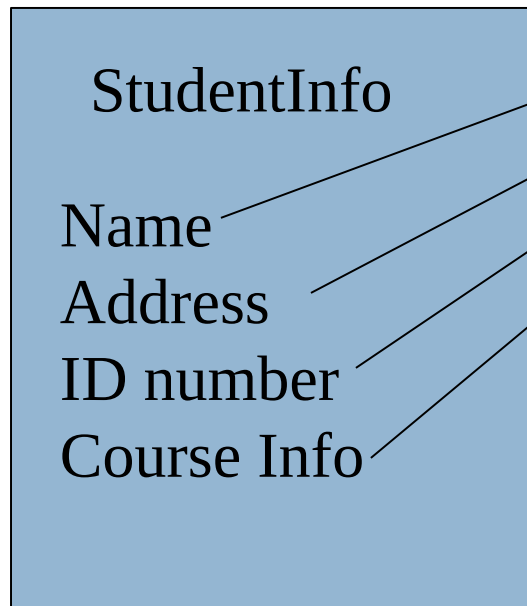
    long length = read.Length;
    //Move the File Ponter in the middle of the name:
    read.Seek(length / 2, SeekOrigin.Begin);
    int middle = read.ReadByte();
    Console.WriteLine("The Middle Character is: \"{0}\" ", (char)middle);

    //Move the file pointer before one character from the end:
    read.Seek(-1, SeekOrigin.End);
    int last = read.ReadByte();
    Console.WriteLine("The Last Character is: \"{0}\" ", (char)last);
}
```

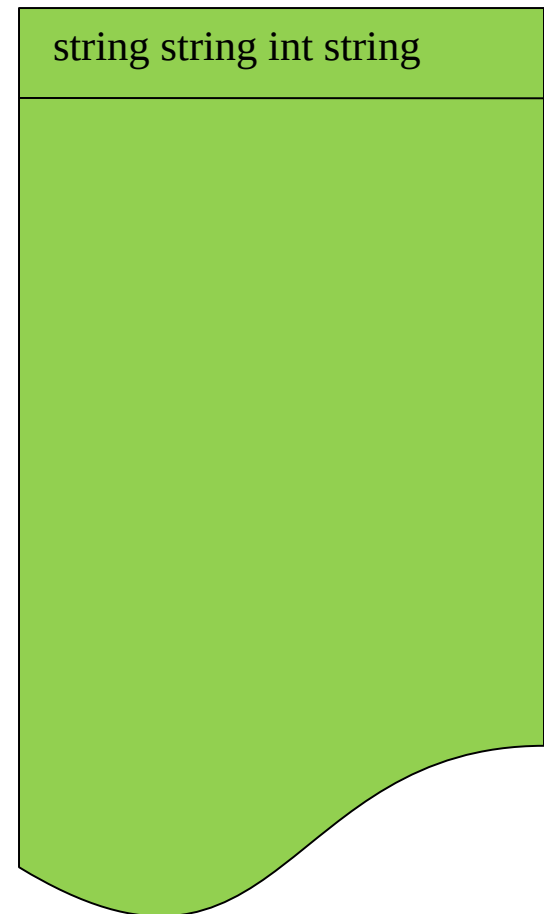
Serialization

- It is easy to write the individual fields of a *record* object to a file
- For example, we can create a record that stores information about a student
 - Name
 - Address
 - ID number
 - Course enrolled for
 - etc
- We can output each field of this record to a file (either text or binary)

- Often we want to store a complete object in a stream.
 - This is achieved by a process called object **serialization**.
 - By serialization we mean converting an object, or a connected graph of objects (a set of objects with some set of references to each other), stored within memory into a linear sequence of bytes.
 - This string of bytes contains all of the information that was held in the object started with.



Record file



- To serialize an object, the object class needs to be marked with the **[Serializable]** attribute or needs to implement the *ISerializable* interface
 - Requires the **System.Runtime.Serialization** namespace
- Also we require a **BinaryFormatter** object to serialize/de-serialize the object before writing to or reading from file
 - using
System.Runtime.Serialization.Formatters.Binary;
 - using System.Runtime.Serialization;

Writing and Reading an Object

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□ Writing Objects

- `BinaryFormatter formatter= new BinaryFormatter();`
- `FileStream output =new FileStream(fileName, FileMode.Open, FileAccess.Write );`
- ...
- `formatter.Serialize( output, record);`

□ Reading an object

- `BinaryFormatter reader = new BinaryFormatter();`
- `FileStream input=new FileStream(fileName, FileMode.Open, FileAccess.Read );`
- `Object obj= reader.Deserialize( input );`

Example

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```
[Serializable]
class Course
{
    string courseTitle, courseCode;
    public Course()
    {
    }
    public Course(string title, string code)
    {
        courseTitle = title;
        courseCode = code;
    }
    static void Main(string[] args)
    {
        Course c1 = new Course("Introduction to Programming", "CS200");
        Course c2 = new Course("Introduction to Database", "CS201");
        ... ←
        Console.ReadKey();
    }
}
```

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... writing

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```
...  
BinaryFormatter formatter = new BinaryFormatter();  
FileStream output = new FileStream(fileName, FileMode.OpenOrCreate,  
                                   FileAccess.ReadWrite);  
try  
{  
    formatter.Serialize(output, c1);  
    formatter.Serialize(output, c2);  
}  
catch (SerializationException e)  
{  
    Console.WriteLine(e.Message.ToString());  
}  
finally  
{  
    output.Close();  
}
```

... reading

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...
↓

```
BinaryFormatter bfl = new BinaryFormatter();
FileStream fs1 = new FileStream(fileName, FileMode.
OpenOrCreate, FileAccess.ReadWrite);
try
{
    while (fs1.Position!=fs1.Length)
    {
        Student s = (Student)bfl.Deserialize(fs1);
        Console.WriteLine("First Name:" + s.Name);
        Console.WriteLine("First Name:" + s.Id);
    }
}
catch (SerializationException)
{
    Console.WriteLine("Error");
}
finally
{
    fs1.Close();
}
```

Exercise 2:

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2. (File of Student Grades) Create a program that stores student grades in a text file. The file should contain the name, ID number, class taken and grade of every student.
 - The entries should be displayed in the following format:
LastName, FirstName: ID# Class Grade

Some sample data below:

Jones, Bob: 1 "Introduction to Computer Science" "A-"

Johnson, Sarah: 2 "Data Structures" "B+"

Smith, Sam: 3 "Data Structures" "C"

Exercise 3:

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3. (File of Student Grades: **Serialization**)
Create a program that stores student objects in a text file. The file should contain the name, ID number, class taken and grade of every student.
 - The entries should be displayed in the following format:
LastName, FirstName: ID# Class Grade

Some sample data below:

Jones, Bob: 1 "Introduction to Computer Science" "A-"

Johnson, Sarah: 2 "Data Structures" "B+"

Smith, Sam: 3 "Data Structures" "C"

Questions?

Thank You