

# Comp 249

## Programming Methodology

### Chapter 10 – *File I/O*

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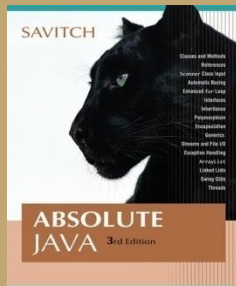
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# Streams

- A *stream* is an object that enables the flow of data between a program and some I/O device or file
  - If the data flows into a program, then the stream is called an *input stream*
  - If the data flows out of a program, then the stream is called an *output stream*

# Streams

- Input streams can flow from the keyboard or from a file

- **System.in** is an input stream that connects to the keyboard

```
Scanner kb = new Scanner(System.in);
```

- Output streams can flow to a screen or to a file

- **System.out** is an output stream that connects to the screen

```
System.out.println("Output stream");
```

# Text Files and Binary Files

- Files that are designed to be read by human beings, and that can be read or written with an editor are called *text files*
  - Text files can also be called ASCII (American Standard Code for Information Interchange) files because the data they contain uses an ASCII encoding scheme
  - An advantage of text files is that they are usually the same on all computers, so that they can move from one computer to another



# Text Files and Binary Files

- Files that are designed to be read by programs and that consist of a sequence of binary digits are called *binary files*
  - Binary files are designed to be read on the same type of computer and with the same programming language as the computer that created the file
  - An advantage of binary files is that they are *more efficient to process* than text files
  - Unlike most binary files, Java binary files have the advantage of being platform independent also

# Writing to a Text File

- The class **PrintWriter** is a stream class that can be used to write to a text file
  - An object of the class **PrintWriter** has the methods **print** and **println**
  - These are similar to the **System.out** methods of the same names, but are used for text file output, not screen output

# Writing to a Text File

- All the file I/O classes that follow are in the package **java.io**
- So, a program that uses **PrintWriter** will start with a set of **import** statements:

```
import java.io.PrintWriter;  
import java.io.FileOutputStream;  
import java.io.FileNotFoundException;
```
- The class **PrintWriter** has no constructor that takes a file name as its argument
  - It uses another class, **FileOutputStream**, to convert a file name to an object that can be used as the argument to its (the **PrintWriter**) constructor

# Writing to a Text File

- A stream of the class **PrintWriter** is created and connected to a text file for writing as follows:

```
PrintWriter pw;
```

```
pw = new PrintWriter(new
```

```
FileOutputStream(fileName) );
```

- The class **FileOutputStream** takes a string representing the file name as its argument
- The class **PrintWriter** takes the anonymous **FileOutputStream** object as its argument

# Writing to a Text File

- This produces an object of the class **PrintWriter** that is connected to the file **FileName**
  - The process of connecting a stream to a file is called *opening the file*
  - If the file already exists, then doing this causes the old contents to be lost
  - If the file does not exist, then a new, empty file named **FileName** is created
- After doing this, the methods **print** and **println** can be used to write to the file

# Writing to a Text File

- When a text file is opened this way, a **FileNotFoundException** may be thrown
  - In this context it actually means that the file could not be created
  - This type of exception can also be thrown when a program attempts to open a file for reading and there is no such file
- It is therefore necessary to enclose this code in exception handling blocks
  - The file should be opened inside a **try** block
  - A **catch** block should catch and handle the possible exception
  - The variable that refers to the **PrintWriter** object should be declared outside the block (and initialized to **null**) so that it is not local to the block

# Writing to a Text File

- When a program is finished writing to a file, it should always close the stream connected to that file; i.e.

**`pw.close();`**

- This allows the system to release any resources used to connect the stream to the file
- If the program does not close the file before the program ends, Java will close it automatically, but data loss may occur



# Writing to a Text File

- Output streams connected to files are usually *buffered*
  - Rather than physically writing to the file as soon as possible, the data is saved in a temporary location (*buffer*)
  - When enough data accumulates, or when the method **flush** is invoked, the buffered data is written to the file all at once
  - This is more efficient, since physical writes to a file can be slow



# Writing to a Text File

- The method **close** invokes the method **flush**, thus insuring that all the data is written to the file
  - If a program relies on Java to close the file, and the program terminates abnormally, then any output that was buffered may not get written to the file
  - Also, if a program writes to a file and later reopens it to read from the same file, it will have to be closed first anyway
  - The sooner a file is closed after writing to it, the less likely it is that there will be a problem

# File Names

- The rules for how file names should be formed depend on a given operating system, not Java
  - When a file name is given to a Java constructor for a stream, it is just a string, not a Java identifier (e.g., **"fileName.txt"**)
  - Any suffix used, such as **.txt** has no special meaning to a Java program

# A File Has Two Names

- Every input file and every output file used by a program has two names:
  1. The real file name used by the operating system
  2. The name of the stream that is connected to the file
- The actual file name is used to connect to the stream
- The stream name serves as a temporary name for the file, and is the name that is primarily used within the program

**See *FileIO1.java***

# IOException

- When performing file I/O there are many situations in which an exception, such as **FileNotFoundException**, may be thrown
  - Many of these exception classes are subclasses of the class **IOException**
    - The class **IOException** is the root class for a variety of exception classes having to do with input and/or output
  - These exception classes are all checked exceptions
    - Therefore, they must be caught or declared in a throws clause
- See FileIO2.java**

# Pitfall: a `try` Block is a Block

- Since opening a file can result in an exception, it should be placed inside a `try` block
- If the variable for a `PrintWriter` object needs to be used outside that block, then the variable must be declared outside the block
  - Otherwise it would be local to the block, and could not be used elsewhere
  - If it were declared in the block and referenced elsewhere, the compiler will generate a message indicating that it is an undefined identifier

# Appending to a Text File

- To create a **PrintWriter** object and connect it to a text file for *appending*, a second argument, set to **true**, must be used in the constructor for the **FileOutputStream** object

```
outputStreamName = new PrintWriter(new  
    FileOutputStream(fileName, true));
```

- After this statement, the methods **print**, **println** and/or **printf** can be used to write to the file
- The new text will be written *after the old text* in the file

**See FileIO3.java**



# toString Helps with Text File Output

- If a class has a suitable **toString()** method, and **anObject** is an object of that class, then **anObject** can be used as an argument to **System.out.println**, and it will produce sensible output
- The same thing applies to the methods **print** and **println** of the class **PrintWriter**  
**outputStreamName.println(anObject);**

# Reading From a Text File Using Scanner

- The class **Scanner** can be used for reading from the keyboard as well as reading from a text file
    - Simply replace the argument **System.in** (to the **Scanner** constructor) with a suitable stream that is connected to the text file
- ```
Scanner sc =  
    new Scanner(new FileInputStream(FileName)) ;
```
- Methods of the **Scanner** class for reading input behave the same, whether reading from the keyboard or reading from a text file
    - For example, the **nextInt** and **nextLine** methods

**See FileIO4.java**



# Testing for the End of a Text File with Scanner

- A program that tries to read beyond the end of a file using methods of the **Scanner** class will cause an exception to be thrown
- However, instead of having to rely on an exception to signal the end of a file, the **Scanner** class provides methods such as **hasNextInt** and **hasNextLine**
  - These methods can also be used to check that the next token to be input is a suitable element of the appropriate type

*See FileIO5.java*

*See FileIO6.java*

# Using both Input & Output Files

- Both input and output files are often used within the same program
- All input and output files should always be closed, using the **close()** method, after the program is done utilizing them

*See FileIO7.java*

*See FileIO8.java*

# Methods in the Class Scanner

## (Part 1 of 11)

### Display 10.6    Methods in the Class Scanner

---

Scanner is in the `java.util` package.

```
public Scanner(InputStream streamObject)
```

There is no constructor that accepts a file name as an argument. If you want to create a stream using a file name, you can use

```
new Scanner(new FileInputStream(File_Name))
```

When used in this way, the `FileInputStream` constructor, and thus the `Scanner` constructor invocation, can throw a `FileNotFoundException`, which is a kind of `IOException`.

To create a stream connected to the keyboard, use

```
new Scanner(System.in)
```

(continued)

# Methods in the Class Scanner

## (Part 2 of 11)

### Display 10.6    Methods in the Class Scanner

---

```
public Scanner(File fileObject)
```

The File class will be covered in the section entitled “The File Class,” later in this chapter. We discuss it here so that you will have a more complete reference in this display, but you can ignore this entry until after you’ve read that section.

If you want to create a stream using a file name, you can use

```
new Scanner(new File(File_Name))
```

```
public int nextInt()
```

Returns the next token as an int, provided the next token is a well-formed string representation of an int.

Throws a NoSuchElementException if there are no more tokens.

Throws an InputMismatchException if the next token is not a well-formed string representation of an int.

Throws an IllegalStateException if the Scanner stream is closed.

(continued)

# Methods in the Class Scanner

## (Part 3 of 11)

### Display 10.6    Methods in the Class Scanner

---

```
public boolean hasNextInt()
```

Returns true if the next token is a well-formed string representation of an int; otherwise returns false.  
Throws an `IllegalStateException` if the Scanner stream is closed.

```
public long nextLong()
```

Returns the next token as a long, provided the next token is a well-formed string representation of a long.

Throws a `NoSuchElementException` if there are no more tokens.

Throws an `InputMismatchException` if the next token is not a well-formed string representation of a long.

Throws an `IllegalStateException` if the Scanner stream is closed.

(continued)

# Methods in the Class Scanner

## (Part 4 of 11)

### Display 10.6    Methods in the Class Scanner

---

```
public boolean hasNextLong()
```

Returns true if the next token is a well-formed string representation of a long; otherwise returns false.

Throws an `IllegalStateException` if the Scanner stream is closed.

```
public byte nextByte()
```

Returns the next token as a byte, provided the next token is a well-formed string representation of a byte.

Throws a `NoSuchElementException` if there are no more tokens.

Throws an `InputMismatchException` if the next token is not a well-formed string representation of a byte.

Throws an `IllegalStateException` if the Scanner stream is closed.

(continued)

# Methods in the Class Scanner

## (Part 5 of 11)

### Display 10.6    Methods in the Class Scanner

---

```
public boolean hasNextByte()
```

Returns true if the next token is a well-formed string representation of a byte; otherwise returns false.

Throws an `IllegalStateException` if the Scanner stream is closed.

```
public short nextShort()
```

Returns the next token as a short, provided the next token is a well-formed string representation of a short.

Throws a `NoSuchElementException` if there are no more tokens.

Throws an `InputMismatchException` if the next token is not a well-formed string representation of a short.

Throws an `IllegalStateException` if the Scanner stream is closed.

(continued)



# Methods in the Class Scanner

## (Part 6 of 11)

### Display 10.6    Methods in the Class Scanner

---

```
public boolean hasNextShort()
```

Returns true if the next token is a well-formed string representation of a short; otherwise returns false.

Throws an `IllegalStateException` if the Scanner stream is closed.

```
public double nextDouble()
```

Returns the next token as a double, provided the next token is a well-formed string representation of a double.

Throws a `NoSuchElementException` if there are no more tokens.

Throws an `InputMismatchException` if the next token is not a well-formed string representation of a double.

Throws an `IllegalStateException` if the Scanner stream is closed.

(continued)



# Methods in the Class Scanner

## (Part 7 of 11)

### Display 10.6    Methods in the Class Scanner

---

```
public boolean hasNextDouble()
```

Returns true if the next token is a well-formed string representation of a double; otherwise returns false.

Throws an `IllegalStateException` if the Scanner stream is closed.

```
public float nextFloat()
```

Returns the next token as a float, provided the next token is a well-formed string representation of a float.

Throws a `NoSuchElementException` if there are no more tokens.

Throws an `InputMismatchException` if the next token is not a well-formed string representation of a float.

Throws an `IllegalStateException` if the Scanner stream is closed.

(continued)

# Methods in the Class Scanner

## (Part 8 of 11)

### Display 10.6    Methods in the Class Scanner

---

```
public boolean hasNextFloat()
```

Returns true if the next token is a well-formed string representation of an float; otherwise returns false.

Throws an `IllegalStateException` if the Scanner stream is closed.

```
public String next()
```

Returns the next token.

Throws a `NoSuchElementException` if there are no more tokens.

Throws an `IllegalStateException` if the Scanner stream is closed.

(continued)

# Methods in the Class Scanner

## (Part 9 of 11)

### Display 10.6    Methods in the Class Scanner

---

```
public boolean hasNext()
```

Returns true if there is another token. May wait for a next token to enter the stream.

Throws an `IllegalStateException` if the Scanner stream is closed.

```
public boolean nextBoolean()
```

Returns the next token as a boolean value, provided the next token is a well-formed string representation of a boolean.

Throws a `NoSuchElementException` if there are no more tokens.

Throws an `InputMismatchException` if the next token is not a well-formed string representation of a boolean value.

Throws an `IllegalStateException` if the Scanner stream is closed.

(continued)

# Methods in the Class Scanner

## (Part 10 of 11)

### Display 10.6    **Methods in the Class Scanner**

---

```
public boolean hasNextBoolean()
```

Returns true if the next token is a well-formed string representation of a boolean value; otherwise returns false.

Throws an `IllegalStateException` if the Scanner stream is closed.

```
public String nextLine()
```

Returns the rest of the current input line. Note that the line terminator '`\n`' is read and discarded; it is not included in the string returned.

Throws a `NoSuchElementException` if there are no more lines.

Throws an `IllegalStateException` if the Scanner stream is closed.

(continued)

# Methods in the Class Scanner

## (Part 11 of 11)

### Display 10.6    Methods in the Class Scanner

---

```
public boolean hasNextLine()
```

Returns true if there is a next line. May wait for a next line to enter the stream.

Throws an `IllegalStateException` if the Scanner stream is closed.

```
public Scanner useDelimiter(String newDelimiter);
```

Changes the delimiter for input so that `newDelimiter` will be the only delimiter that separates words or numbers. See the subsection “Other Input Delimiters” in Chapter 2 for the details. (You can use this method to set the delimiters to a more complex pattern than just a single string, but we are not covering that.)

Returns the calling object, but we have always used it as a void method.

# Reading From a Text File Using BufferedReader

- The class **BufferedReader** is a stream class that can be used to read from a text file
  - An object of the class **BufferedReader** has the methods **read** and **readLine**
- A program using **BufferedReader**, like one using **PrintWriter**, or **Scanner** will start with a set of **import** statements:

```
import java.io.BufferedReader;  
import java.io.FileReader;  
import java.io.FileNotFoundException;  
import java.io.IOException;
```

# Reading From a Text File Using BufferedReader

- Like the classes **PrintWriter** and **Scanner**, **BufferedReader** has no constructor that takes a file name as its argument
  - It needs to use another class, **FileReader**, to convert the file name to an object that can be used as an argument to its (the **BufferedReader**) constructor
- A stream of the class **BufferedReader** is created and connected to a text file as follows:

```
BufferedReader readerObject;  
readerObject = new BufferedReader(new  
FileReader (FileName) ) ;
```

  - This opens the file for reading



# Reading From a Text File

- After these statements, the methods **read** and **readLine** can be used to read from the file
  - The **readLine** method is the same method used to read from the keyboard, but in this case it would read from a file
  - The **read** method reads a single character, and returns a value (of type **int**) that corresponds to the character read
  - Since the read method does not return the character itself, a type cast must be used:  
**char next = (char) (readerObject.read()) ;**



# Reading From a Text File

- A program using a **BufferedReader** object in this way may throw two kinds of exceptions
  - An attempt to open the file may throw a **FileNotFoundException** (which in this case has the expected meaning)
  - An invocation of **readLine** may throw an **IOException**
  - Both of these exceptions should be handled

*See FileIO9.java*

# Testing for the End of a Text File

- The method **readLine** of the class **BufferedReader** returns **null** when it tries to read beyond the end of a text file
  - A program can test for the end of the file by testing for the value **null** when using **readLine**
- The method **read** of the class **BufferedReader** returns **-1** when it tries to read beyond the end of a text file
  - A program can test for the end of the file by testing for the value **-1** when using **read**

# Some Methods of the Class BufferedReader (Part 1 of 2)

## Display 10.8 Some Methods of the Class BufferedReader

---

BufferedReader and FileReader are in the `java.io` package.

```
public BufferedReader(Reader readerObject)
```

This is the only constructor you are likely to need. There is no constructor that accepts a file name as an argument. If you want to create a stream using a file name, you use

```
new BufferedReader(new FileReader(File_Name))
```

When used in this way, the `FileReader` constructor, and thus the `BufferedReader` constructor invocation, can throw a `FileNotFoundException`, which is a kind of `IOException`.

The `File` class will be covered in the section entitled "The File Class." We discuss it here so that you will have a more complete reference in this display, but you can ignore the following reference to the class `File` until after you've read that section.

If you want to create a stream using an object of the class `File`, you use

```
new BufferedReader(new FileReader(File_Object))
```

When used in this way, the `FileReader` constructor, and thus the `BufferedReader` constructor invocation, can throw a `FileNotFoundException`, which is a kind of `IOException`.

(continued)

# Some Methods of the Class BufferedReader (Part 2 of 2)

## Display 10.8 Some Methods of the Class BufferedReader

---

```
public String readLine() throws IOException
```

Reads a line of input from the input stream and returns that line. If the read goes beyond the end of the file, null is returned. (Note that an EOFException is not thrown at the end of a file. The end of a file is signaled by returning null.)

```
public int read() throws IOException
```

Reads a single character from the input stream and returns that character as an int value. If the read goes beyond the end of the file, then -1 is returned. Note that the value is returned as an int. To obtain a char, you must perform a type cast on the value returned. The end of a file is signaled by returning -1. (All of the “real” characters return a positive integer.)

```
public long skip(long n) throws IOException
```

Skips n characters.

```
public void close() throws IOException
```

Closes the stream’s connection to a file.

# Reading Numbers

- Unlike the **Scanner** class, the class **BufferedReader** has no methods to read a number from a text file
  - Instead, a number must be read in as a string, and then converted to a value of the appropriate numeric type using one of the wrapper classes
  - To read in a single number on a line by itself, first use the method **readLine**, and then use **Integer.parseInt**, **Double.parseDouble**, etc. to convert the string into a number
  - If there are multiple numbers on a line, **StringTokenizer** can be used to decompose the string into tokens, and then the tokens can be converted as described above

# Path Names

- When a file name is used as an argument to a constructor for opening a file, it is assumed that the file is in the same directory or folder as the one in which the program is run
- If it is not in the same directory, the full or relative path name must be given



# Path Names

- A *path name* not only gives the name of the file, but also the directory or folder in which the file exists
- A *full path name* gives a complete path name, starting from the root directory
- A *relative path name* gives the path to the file, starting with the directory in which the program is located



# Path Names

- The way path names are specified depends on the operating system
  - A typical UNIX path name that could be used as a file name argument is  
`"/user/Mike/Comp249/Assg2/data.txt"`
  - A **BufferedReader** input stream connected to this file is created as follows:  

```
BufferedReader inputStream =  
    new BufferedReader(new  
        FileReader("/user/Mike/Comp249/Assg2/data.txt")) ;
```

# Path Names

- The Windows operating system specifies path names in a different way
  - An example of Windows path name is as follows:  
**C:\Concordia\Comp249\Assg2\data.txt**
  - A **BufferedReader** input stream connected to this file is created as follows:  
**BufferedReader inputStream = new  
BufferedReader(new FileReader  
("C:\\Concordia\\Comp249\\Assg2\\data.txt")) ;**
  - Note that in Windows **\\** must be used in place of **\**, since a single backslash denotes the beginning of an escape sequence

# Path Names

- A double backslash (\\) must be used for a Windows path name enclosed in a quoted string
  - This problem does not occur with path names read in from the keyboard
- Problems with escape characters can be avoided altogether by always using UNIX conventions when writing a path name

```
BufferedReader inputStream = new  
BufferedReader(new FileReader  
("C:/Concordia/Comp249/Assg2/data.txt")) ;
```

- A Java program will accept a path name written in either Windows or Unix format regardless of the operating system on which it is run

# Nested Constructor Invocations

- Each of the Java I/O library classes serves only one function, or a small number of functions
  - Normally two or more class constructors are combined to obtain full functionality
- Therefore, expressions with two constructors are common when dealing with Java I/O classes

# Nested Constructor Invocations

```
new BufferedReader(new FileReader("stuff.txt"))
```

- Above, the anonymous **FileReader** object establishes a connection with the **stuff.txt** file
  - However, it provides only very primitive methods for input
- The constructor for **BufferedReader** takes this **FileReader** object and adds a richer collection of input methods
  - This transforms the inner object into an instance variable of the outer object

# System.in, System.out, and System.err

- The standard streams **System.in**, **System.out**, and **System.err** are automatically available to every Java program
  - **System.out** is used for normal screen output
  - **System.err** is used to output error messages to the screen
- The **System** class provides three methods (**setIn**, **setOut**, and **setErr**) for redirecting these standard streams:

```
public static void setIn(InputStream inStream)
public static void setOut(PrintStream outStream)
public static void setErr(PrintStream outStream)
```

# System.in, System.out, and System.err

- Using these methods, any of the three standard streams can be redirected
  - For example, instead of appearing on the screen, error messages could be redirected to a file
- In order to redirect a standard stream, a new stream object is created
  - Like other streams created in a program, a stream object used for redirection must be closed after I/O is finished
  - Note, standard streams do not need to be closed



# System.in, System.out, and System.err

## ■ Redirecting **System.err**:

```
public void getInput()
{
    . . .
    PrintStream errStream = null;
    try
    {
        errStream = new PrintStream(new
            FileOutputStream("errMessages.txt"));
        System.setErr(errStream);
        . . . //Set up input stream
    }
}
```

# System.in, System.out, and System.err

```
catch (FileNotFoundException e)
{
    System.err.println("Input file not found");
}
finally
{
    . . .
    errStream.close();
}
}
```

# The File Class

- The **File** class is like a wrapper class for file names
  - The constructor for the class **File** takes a name, (known as the *abstract name*) as a string argument, and produces an object that represents the file with that name
  - The **File** object and methods of the class **File** can be used to determine information about the file and its properties

# Some Methods in the Class `File`

## (Part 1 of 5)

### Display 10.12 Some Methods in the Class `File`

---

`File` is in the `java.io` package.

```
public File(String File_Name)
```

Constructor. *File\_Name* can be either a full or a relative path name (which includes the case of a simple file name). *File\_Name* is referred to as the **abstract path name**.

```
public boolean exists()
```

Tests whether there is a file with the abstract path name.

```
public boolean canRead()
```

Tests whether the program can read from the file. Returns `true` if the file named by the abstract path name exists and is readable by the program; otherwise returns `false`.

(continued)

# Some Methods in the Class File

## (Part 2 of 5)

### Display 10.12 Some Methods in the Class File

---

```
public boolean setReadOnly()
```

Sets the file represented by the abstract path name to be read only. Returns `true` if successful; otherwise returns `false`.

```
public boolean canWrite()
```

Tests whether the program can write to the file. Returns `true` if the file named by the abstract path name exists and is writable by the program; otherwise returns `false`.

```
public boolean delete()
```

Tries to delete the file or directory named by the abstract path name. A directory must be empty to be removed. Returns `true` if it was able to delete the file or directory. Returns `false` if it was unable to delete the file or directory.

(continued)

# Some Methods in the Class `File`

## (Part 3 of 5)

### Display 10.12 Some Methods in the Class `File`

---

```
public boolean createNewFile() throws IOException
```

Creates a new empty file named by the abstract path name, provided that a file of that name does not already exist. Returns `true` if successful, and returns `false` otherwise.

```
public String getName()
```

Returns the last name in the abstract path name (that is, the simple file name). Returns the empty string if the abstract path name is the empty string.

```
public String getPath()
```

Returns the abstract path name as a `String` value.

```
public boolean renameTo(File New_Name)
```

Renames the file represented by the abstract path name to *New\_Name*. Returns `true` if successful; otherwise returns `false`. *New\_Name* can be a relative or absolute path name. This may require moving the file. Whether or not the file can be moved is system dependent.

(continued)

# Some Methods in the Class `File`

## (Part 4 of 5)

### Display 10.12 Some Methods in the Class `File`

---

```
public boolean isFile()
```

Returns true if a file exists that is named by the abstract path name and the file is a normal file; otherwise returns false. The meaning of *normal* is system dependent. Any file created by a Java program is guaranteed to be normal.

```
public boolean isDirectory()
```

Returns true if a directory (folder) exists that is named by the abstract path name; otherwise returns false.

(continued)



# Some Methods in the Class File

## (Part 5 of 5)

### Display 10.12 Some Methods in the Class File

---

```
public boolean mkdir()
```

Makes a directory named by the abstract path name. Will not create parent directories. See `makedirs`. Returns `true` if successful; otherwise returns `false`.

```
public boolean mkdirs()
```

Makes a directory named by the abstract path name. Will create any necessary but nonexistent parent directories. Returns `true` if successful; otherwise returns `false`. Note that if it fails, then some of the parent directories may have been created.

```
public long length()
```

Returns the length in bytes of the file named by the abstract path name. If the file does not exist or the abstract path name names a directory, then the value returned is not specified and may be anything.

*See `FileIO10.java`*

*See `FileIO11.java`*

# Binary Files

- Binary files store data in the same format used by computer memory to store the values of variables
  - No conversion needs to be performed when a value is stored or retrieved from a binary file
- Java binary files, unlike other binary language files, are portable
  - A binary file created by a Java program can be moved from one computer to another
  - These files can then be read by a Java program, but only by a Java program

# Writing Simple Data to a Binary File

- The class **ObjectOutputStream** is a stream class that can be used to write to a binary file
  - An object of this class has methods to write strings, values of primitive types, and objects to a binary file
- A program using **ObjectOutputStream** needs to import several classes from package **java.io**:

```
import java.io.ObjectOutputStream;  
import java.io.FileOutputStream;  
import java.io.IOException;
```

# Opening a Binary File for Output

- An **ObjectOutputStream** object is created and connected to a binary file as follows:

```
ObjectOutputStream outputStreamName = new  
    ObjectOutputStream(new  
        FileOutputStream(fileName) );
```

- The constructor for **FileOutputStream** may throw a **FileNotFoundException**
- The constructor for **ObjectOutputStream** may throw an **IOException**
- Each of these must be handled

# Opening a Binary File for Output

- After opening the file, **ObjectOutputStream** methods can be used to write to the file
  - Methods used to output primitive values include **writeInt**, **writeDouble**, **writeChar**, and **writeBoolean**
- *UTF (Universal Transformation Format)* is an encoding scheme used to encode Unicode characters that favors the ASCII character set
  - The method **writeUTF** can be used to output values of type **String**
- The stream should always be closed after writing  
**See FileIO12.java**

# Some Methods in the Class ObjectOutputStream (Part 1 of 5)

## Display 10.14 Some Methods in the Class ObjectOutputStream

ObjectOutputStream and FileOutputStream are in the `java.io` package.

```
public ObjectOutputStream(OutputStream streamObject)
```

There is no constructor that takes a file name as an argument. If you want to create a stream using a file name, you use

```
new ObjectOutputStream(new FileOutputStream(File_Name))
```

This creates a blank file. If there already is a file named *File\_Name*, then the old contents of the file are lost.

If you want to create a stream using an object of the class `File`, you use

```
new ObjectOutputStream(new FileOutputStream(File_Object))
```

The constructor for `FileOutputStream` may throw a `FileNotFoundException`, which is a kind of `IOException`. If the `FileOutputStream` constructor succeeds, then the constructor for `ObjectOutputStream` may throw a different `IOException`.

(continued)

# Some Methods in the Class `ObjectOutputStream` (Part 2 of 5)

## Display 10.14 Some Methods in the Class `ObjectOutputStream`

---

```
public void writeInt(int n) throws IOException
```

Writes the `int` value `n` to the output stream.

```
public void writeShort(short n) throws IOException
```

Writes the `short` value `n` to the output stream.

```
public void writeLong(long n) throws IOException
```

Writes the `long` value `n` to the output stream.

```
public void writeDouble(double x) throws IOException
```

Writes the `double` value `x` to the output stream.

(continued)



# Some Methods in the Class `ObjectOutputStream` (Part 3 of 5)

## Display 10.14 Some Methods in the Class `ObjectOutputStream`

---

```
public void writeFloat(float x) throws IOException
```

Writes the float value `x` to the output stream.

```
public void writeChar(int n) throws IOException
```

Writes the char value `n` to the output stream. Note that it expects its argument to be an `int` value. However, if you simply use the char value, then Java will automatically type cast it to an `int` value. The following are equivalent:

```
outputStream.writeChar((int)'A');
```

and

```
outputStream.writeChar('A');
```

(continued)

# Some Methods in the Class ObjectOutputStream (Part 4 of 5)

## Display 10.14 Some Methods in the Class ObjectOutputStream

---

```
public void writeBoolean(boolean b) throws IOException
```

Writes the boolean value b to the output stream.

```
public void writeUTF(String aString) throws IOException
```

Writes the String value aString to the output stream. UTF refers to a particular method of encoding the string. To read the string back from the file, you should use the method readUTF of the class ObjectInputStream.

(continued)

# Some Methods in the Class `ObjectOutputStream` (Part 5 of 5)

## Display 10.14    Some Methods in the Class `ObjectOutputStream`

---

```
public void writeObject(Object anObject) throws IOException
```

Writes its argument to the output stream. The object argument should be an object of a serializable class, a concept discussed later in this chapter. Throws various `IOException`s.

```
public void close() throws IOException
```

Closes the stream's connection to a file. This method calls `flush` before closing the file.

```
public void flush() throws IOException
```

Flushes the output stream. This forces an actual physical write to the file of any data that has been buffered and not yet physically written to the file. Normally, you should not need to invoke `flush`.

# Reading Simple Data from a Binary File

- The class **ObjectInputStream** is a stream class that can be used to read from a binary file
  - An object of this class has methods to read strings, values of primitive types, and objects from a binary file
- A program using **ObjectInputStream** needs to import several classes from package **java.io**:

```
import java.io.ObjectInputStream;  
import java.io.FileInputStream;  
import java.io.IOException;
```

# Opening a Binary File for Reading

- An **ObjectInputStream** object is created and connected to a binary file as follows:

```
ObjectInputStream inStreamName = new  
    ObjectInputStream(new  
    FileInputStream(fileName) );
```

- The constructor for **FileInputStream** may throw a **FileNotFoundException**
- The constructor for **ObjectInputStream** may throw an **IOException**
- Each of these must be handled

# Opening a Binary File for Reading

- After opening the file, **ObjectInputStream** methods can be used to read to the file
  - Methods used to input primitive values include **readInt**, **readDouble**, **readChar**, and **readBoolean**
  - The method **readUTF** is used to input values of type **String**
- If the file contains multiple types, each item type must be read in exactly the same order it was written to the file
- The stream should be closed after reading

**See FileIO13.java**

# Some Methods in the Class `ObjectInputStream`

## (Part 1 of 5)

### Display 10.15    Some Methods in the Class `ObjectInputStream`

---

The classes `ObjectInputStream` and `FileInputStream` are in the `java.io` package.

```
public ObjectInputStream(InputStream streamObject)
```

There is no constructor that takes a file name as an argument. If you want to create a stream using a file name, you use

```
new ObjectInputStream(new FileInputStream(File_Name))
```

Alternatively, you can use an object of the class `File` in place of the *File\_Name*, as follows:

```
new ObjectInputStream(new FileInputStream(File_Object))
```

The constructor for `FileInputStream` may throw a `FileNotFoundException`, which is a kind of `IOException`. If the `FileInputStream` constructor succeeds, then the constructor for `ObjectInputStream` may throw a different `IOException`.

(continued)



# Some Methods in the Class `ObjectInputStream`

## (Part 2 of 5)

### Display 10.15    Some Methods in the Class `ObjectInputStream`

---

```
public int readInt() throws IOException
```

Reads an `int` value from the input stream and returns that `int` value. If `readInt` tries to read a value from the file and that value was not written using the method `writeInt` of the class `ObjectOutputStream` (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
public int readShort() throws IOException
```

Reads a `short` value from the input stream and returns that `short` value. If `readShort` tries to read a value from the file and that value was not written using the method `writeShort` of the class `ObjectOutputStream` (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

(continued)

# Some Methods in the Class `ObjectInputStream`

## (Part 3 of 5)

### Display 10.15    Some Methods in the Class `ObjectInputStream`

---

```
public long readLong() throws IOException
```

Reads a long value from the input stream and returns that long value. If `readLong` tries to read a value from the file and that value was not written using the method `writeLong` of the class `ObjectOutputStream` (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
public double readDouble() throws IOException
```

Reads a double value from the input stream and returns that double value. If `readDouble` tries to read a value from the file and that value was not written using the method `writeDouble` of the class `ObjectOutputStream` (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
public float readFloat() throws IOException
```

Reads a float value from the input stream and returns that float value. If `readFloat` tries to read a value from the file and that value was not written using the method `writeFloat` of the class `ObjectOutputStream` (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

(continued)

# Some Methods in the Class `ObjectInputStream`

## (Part 4 of 5)

### Display 10.15    Some Methods in the Class `ObjectInputStream`

---

```
public char readChar() throws IOException
```

Reads a char value from the input stream and returns that char value. If `readChar` tries to read a value from the file and that value was not written using the method `writeChar` of the class `ObjectOutputStream` (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
public boolean readBoolean() throws IOException
```

Reads a boolean value from the input stream and returns that boolean value. If `readBoolean` tries to read a value from the file and that value was not written using the method `writeBoolean` of the class `ObjectOutputStream` (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

(continued)

# Some Methods in the Class `ObjectInputStream`

## (Part 5 of 5)

### Display 10.15    Some Methods in the Class `ObjectInputStream`

---

```
public String readUTF() throws IOException
```

Reads a `String` value from the input stream and returns that `String` value. If `readUTF` tries to read a value from the file and that value was not written using the method `writeUTF` of the class `ObjectOutputStream` (or written in some equivalent way), then problems will occur. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
Object readObject() throws ClassNotFoundException, IOException
```

Reads an object from the input stream. The object read should have been written using `writeObject` of the class `ObjectOutputStream`. Throws a `ClassNotFoundException` if a serialized object cannot be found. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown. May throw various other `IOExceptions`.

```
public int skipBytes(int n) throws IOException
```

Skips `n` bytes.

```
public void close() throws IOException
```

Closes the stream's connection to a file.

# Checking for the End of a Binary File the Correct Way

- All of the **ObjectInputStream** methods that read from a binary file throw an **EOFException** when trying to read beyond the end of a file
  - This can be used to end a loop that reads all the data in a file
- Note that different file-reading methods check for the end of a file in different ways
  - Testing for the end of a file in the wrong way can cause a program to go into an infinite loop or terminate abnormally



# The Serializable Interface

- In order to make a class serializable, simply add **implements Serializable** to the heading of the class definition  
**public class SomeClass implements Serializable**
- If a class is **Serializable**, Java assigns a serial number to objects of this class being written to a stream of type ObjectOutputStream

# The Serializable Interface

- When any of these objects is written to the same stream more than once, then after the first time, only its serial number is written, instead of the object full description , which is very efficient
- Why not all object are serializable?
  - 1) Security: the serial numbering system allows easier access to objects on secondary storage through the serial numbers
  - 2) Sometimes, it does not make sense to write objects to secondary storage at all; for instance if the object include system-specific data
    - In such case, if the binary file is moved from one system to another then it is actually senseless since the object information may no longer be valid



# The Serializable Interface

- When a serializable class has instance variables of a class type (that is *composition*), then all those classes must also be serializable

# Binary I/O of Objects

- If a class is serializable, objects of this class can also be input to and output from a binary file
  - The **writeObject()** method of the **ObjectOutputStream** class is used to write an object to a binary file
  - The **readObject()** method of the **ObjectInputStream** class is used to read an object from a binary file
  - In order to use the value returned by **readObject()** as an object of a class, it must be type cast first:

```
Car c1 = (Car) objectInputStream.readObject();
```

- It is best to store the data of only one class type in any one file
  - Storing objects of multiple class types or objects of one class type mixed with primitives can lead to loss of data

**See FileIO14.java**

# Array Objects in Binary Files

- Since an array is an object, arrays can also be read and written to binary files using **readObject** and **writeObject**
  - If the base type is a class, then it must also be serializable, just like any other class type
  - Since **readObject** returns its value as type **Object** (like any other object), it must be type cast to the correct array type:

```
Car[] carArr =  
    (Car[])objectInputStream.readObject();
```

# Random Access to Binary Files

- The streams for sequential access to files are the ones most commonly used for file access in Java
- However, some applications require very rapid access to records in very large databases
  - These applications need to have random/direct access to particular parts of a file

# Random Reading and Writing to Files

- The stream class **RandomAccessFile**, which is in the **java.io** package, provides both read and write random access to a file in Java
- A random access file consists of a sequence of numbered bytes
  - There is a kind of marker called the *file pointer* that is always positioned at one of the bytes
  - All reads and writes take place starting at the *file pointer location*
  - The file pointer can be moved to a new location with the method **seek**

# Random Reading and Writing to Files

- Although a random access file is byte oriented, there are methods that allow for reading or writing values of the primitive types as well as string values to/from a random access file
  - These include **readInt**, **readDouble**, and **readUTF** for input, and **writeInt**, **writeDouble**, and **writeUTF** for output
  - It does not have **writeObject** or **readObject** methods, however

# Opening a File

- The constructor for **RandomAccessFile** takes either a string file name or an object of the class **File** as its first argument
- The second argument must be one of four strings:
  - **"rw"**, meaning the code can both read and write to the file after it is open
  - **"r"**, meaning the code can read from the file, but not write to it
  - **"rws"** or **"rwd"** (See Table of methods from **RandomAccessFile**)

*See FileIO15.java*



# Pitfall: A Random Access File Need Not Start Empty

- If the file already exists, then when it is opened, the length is not reset to 0, and the file pointer will be positioned at the start of the file
  - This ensures that old data is not lost, and that the file pointer is set for the most likely position for reading (not writing)
- The length of the file can be changed with the **setLength** method
  - In particular, the **setLength** method can be used to empty the file

# Some Methods of the Class `RandomAccessFile`

## (Part 1 of 7)

### Display 10.21 Some Methods of the Class `RandomAccessFile`

---

The class `RandomAccessFile` is in the `java.io` package.

```
public RandomAccessFile(String fileName, String mode)
```

```
public RandomAccessFile(File fileObject, String mode)
```

Opens the file, does not delete data already in the file, but does position the file pointer at the first (zeroth) location.

The mode must be one of the following:

- "r" Open for reading only.

- "rw" Open for reading and writing.

- "rws" Same as "rw", and also requires that every update to the file's content or metadata be written synchronously to the underlying storage device.

- "rwd" Same as "rw", and also requires that every update to the file's content be written synchronously to the underlying storage device.

- "rws" and "rwd" are not covered in this book.

(continued)

# Some Methods of the Class `RandomAccessFile`

## (Part 2 of 7)

### Display 10.21 Some Methods of the Class `RandomAccessFile`

```
public long getFilePointer() throws IOException
```

Returns the current location of the file pointer. Locations are numbered starting with 0.

```
public void seek(long location) throws IOException
```

Moves the file pointer to the specified location.

```
public long length() throws IOException
```

Returns the length of the file.

```
public void setLength(long newLength) throws IOException
```

Sets the length of this file.

If the present length of the file as returned by the `length` method is greater than the `newLength` argument, then the file will be truncated. In this case, if the file pointer location as returned by the `getFilePointer` method is greater than `newLength`, then after this method returns, the file pointer location will be equal to `newLength`.

If the present length of the file as returned by the `length` method is smaller than `newLength`, then the file will be extended. In this case, the contents of the extended portion of the file are not defined.

(continued)

# Some Methods of the Class `RandomAccessFile`

## (Part 3 of 7)

### Display 10.21    Some Methods of the Class `RandomAccessFile`

---

```
public void close() throws IOException
```

Closes the stream's connection to a file.

```
public void write(int b) throws IOException
```

Writes the specified byte to the file.

```
public void write(byte[] a) throws IOException
```

Writes `a.length` bytes from the specified byte array to the file.

```
public final void writeByte(byte b) throws IOException
```

Writes the byte `b` to the file.

```
public final void writeShort(short n) throws IOException
```

Writes the short `n` to the file.

(continued)

# Some Methods of the Class `RandomAccessFile`

## (Part 4 of 7)

### Display 10.21 Some Methods of the Class `RandomAccessFile`

---

```
public final void writeInt(int n) throws IOException
```

Writes the `int` `n` to the file.

```
public final void writeLong(long n) throws IOException
```

Writes the `long` `n` to the file.

```
public final void writeDouble(double d) throws IOException
```

Writes the `double` `d` to the file.

```
public final void writeFloat(float f) throws IOException
```

Writes the `float` `f` to the file.

(continued)

# Some Methods of the Class `RandomAccessFile`

## (Part 5 of 7)

### Display 10.21 Some Methods of the Class `RandomAccessFile`

---

```
public final void writeChar(char c) throws IOException
```

Writes the char `c` to the file.

```
public final void writeBoolean(boolean b) throws IOException
```

Writes the boolean `b` to the file.

```
public final void writeUTF(String s) throws IOException
```

Writes the String `s` to the file.

```
public int read() throws IOException
```

Reads a byte of data from the file and returns it as an integer in the range 0 to 255.

```
public int read(byte[] a) throws IOException
```

Reads `a.length` bytes of data from the file into the array of bytes `a`. Returns the number of bytes read or `-1` if the end of the file is encountered.

(continued)

# Some Methods of the Class `RandomAccessFile`

## (Part 6 of 7)

### Display 10.21    Some Methods of the Class `RandomAccessFile`

---

```
public final byte readByte() throws IOException
```

Reads a byte value from the file and returns that value. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
public final short readShort() throws IOException
```

Reads a short value from the file and returns that value. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
public final int readInt() throws IOException
```

Reads an int value from the file and returns that value. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
public final long readLong() throws IOException
```

Reads a long value from the file and returns that value. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

(continued)



# Some Methods of the Class `RandomAccessFile`

## (Part 7 of 7)

### Display 10.21 Some Methods of the Class `RandomAccessFile`

```
public final double readDouble() throws IOException
```

Reads a double value from the file and returns that value. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
public final float readFloat() throws IOException
```

Reads a float value from the file and returns that value. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
public final char readChar() throws IOException
```

Reads a char value from the file and returns that value. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
public final boolean readBoolean() throws IOException
```

Reads a boolean value from the file and returns that value. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.

```
public final String readUTF() throws IOException
```

Reads a String value from the file and returns that value. If an attempt is made to read beyond the end of the file, an `EOFException` is thrown.