


## File Input and Output (Savitch, Chapter 10)

TOPICS

- File Input
- Exception Handling
- File Output




## File class in Java

- Programmers refer to input/output as "I/O".
- The **File** class represents files as objects.
- The class is defined in the `java.io` package.
- Creating a `File` object allows you to get information about a file on the disk.
- Creating a `File` object does NOT create a new file on your disk.

```
File f = new File("example.txt");
if (f.exists() && f.length() > 1000) {
    f.delete();
}
```

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## Files

- Some methods in the **File** class:

Method name	Description
<code>canRead()</code>	returns whether file can be read
<code>delete()</code>	removes file from disk
<code>exists()</code>	whether this file exists on disk
<code>getName()</code>	returns name of file
<code>length()</code>	returns number of characters in file
<code>renameTo(filename)</code>	changes name of file

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## Scanner reminder

- The **Scanner** class reads input and processes strings and numbers from the user.
- When constructor is called with **System.in**, the character stream is input typed to the console.
- Instantiate **Scanner** by passing the input character stream to the constructor:

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


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## Scanner reminder

- Common methods called on **Scanner**:
  - Read a line  
`String str = scan.nextLine();`
  - Read a string (separated by whitespace)  
`String str = scan.next( );`
  - Read an integer  
`int ival = scan.nextInt( );`
  - Read a double  
`double dval = scan.nextDouble( );`

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## Opening a file for reading

- To read a file, pass a **File** object as a parameter when constructing a **Scanner**
- Scanner** for a file:
 


```
Scanner <name> = new Scanner(new File(<filename>));
```

String variable or string literal
- Example:
 

```
Scanner scan= new Scanner(new File("numbers.txt"));
```
- OR:
 

```
File file = new File("numbers.txt");
Scanner scan= new Scanner(file);
```


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## File names and paths

- relative path**: does not specify any top-level folder, so the path is relative to the current directory:
  - "names.dat"
  - "code/Example.java"
- absolute path**: The complete pathname to a file starting at the root directory /:
  - In Linux: `"/users/cs160/programs/Example.java"`
  - In Windows: `"C:/Documents/cs160/programs/data.csv"`

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## File names and paths

- When you construct a **File** object with a relative path, Java assumes it is relative to the *current directory*.
 

```
Scanner scan =
    new Scanner(new File("data/input.txt"));
```

  - If our program is in `~/workspace/P4`
  - Scanner** will look for `~/workspace/P4/data/input.txt`

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## Compiler error with files


- Question: Why will the following program NOT compile?

```
import java.io.*;    // for File
import java.util.*; // for Scanner

public class ReadFile {
    public static void main(String[] args) {
        File file = new File("input.txt");
        Scanner scan = new Scanner(file);
        String text = scan.next();
        System.out.println(text);
    }
}
```

- Answer: Because of Java exception handling!

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## Compiler error with files

- Here is the compilation error that is produced:
 

```
ReadFile.java:6: unreported exception
java.io.FileNotFoundException;
must be caught or declared to be thrown
Scanner scan = new Scanner(new File("data.txt"));
```
- The problem has to do with error reporting.
- What to do when a file cannot be opened?
- File may not exist, or may be protected.
- Options: exit program, return error, or throw exception
- Exceptions are the normal error mechanism in Java.


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## Exceptions

- exception:** An object that represents a program error.
  - Programs with invalid logic will cause exceptions.
  - Examples:
    - dividing by zero
    - calling `charAt` on a `String` with an out of range index
    - trying to read a file that does not exist
  - We say that a logical error results in an exception being *thrown*.
  - It is also possible to *catch* (handle) an exception.


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## Checked exceptions

- checked exception:** An error that must be handled by our program (otherwise it will not compile).
  - We must specify what our program will do to handle any potential file I/O failures.
  - We must either:
    - declare that our program will handle ("*catch*") the exception, or
    - state that we choose not to handle the exception (and we accept that the program will crash if an exception occurs)

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## Throwing Exceptions


- **throws clause:** Keywords placed on a method's header to state that it may generate an exception.
- It's like a waiver of liability:
  - "I hereby agree that this method might throw an exception, and I accept the consequences (crashing) if this happens."
  - General syntax:

```
public static <type> <name>(<params>) throws <type>
{ ... }
```

- When doing file open, we throw **IOException**.

```
public static void main(String[] args)
    throws IOException {
```

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## Handling Exceptions

- When doing file I/O, we use **IOException**.

```
public static void main(String[] args) {
    try {
        File file = new File("input.txt");
        Scanner scan = new Scanner(file);
        String firstLine = scan.nextLine();
        ...
    } catch (IOException e) {
        System.out.println("Unable to open input.txt");
        System.exit(-1);
    }
}
```


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## Fixing the compiler error

- Throwing an exception or handling the exception both resolve the compiler error.
- Throwing Exceptions: User will see program terminate with exception, that's not very friendly.
- Handling Exceptions: User gets a clear indication of problem with error message, that's much better.
- We will handle exceptions when reading and writing files in programming assignments.

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## Using Scanner to read file data

- Consider a file **numbers.txt** that contains this text:

```
308.2
 14.9 7.4  2.8

3.9 4.7  -15.4
 2.8
```

- A **Scanner** views all input as a stream of characters:

```
□ 308.2\n  14.9 7.4  2.8\n\n3.9 4.7 -15.4\n2.8\n
```

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## Consuming tokens

- Each call to `next`, `nextInt`, `nextDouble`, etc. advances the position of the scanner to the end of the current token, skipping over any whitespace:
- ```
308.2\n 14.9 7.4 2.8\n\n\n3.9 4.7 -15.4\n2.8\n
^
scan.nextDouble();
308.2\n 14.9 7.4 2.8\n\n\n3.9 4.7 -15.4\n2.8\n
^
scan.nextDouble();
308.2\n 14.9 7.4 2.8\n\n\n3.9 4.7 -15.4\n2.8\n
^
```

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## First problem

- Write code that reads the first 5 **double** values from a file and prints.

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## First solution

```
public static void main(String[] args)
try {
    File file = new File("input.txt");
    Scanner scan = new Scanner(file);
    for (int i = 0; i <= 4; i++) {
        double next = scan.nextDouble();
        System.out.println("number = " + next);
    }
} catch (IOException e) {
    System.out.println("Unable to open input.txt");
    System.exit(-1);
}
}
```

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## Second problem

- How would we modify the program to read all the file?

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## Second solution

```
public static void main(String[] args)
try {
    File file = new File("input.txt");
    Scanner scan = new Scanner(file);
    while (scan.hasNextDouble()) {
        double next = scan.nextDouble();
        System.out.println("number = " + next);
    }
} catch (IOException e) {
    System.out.println("Unable to open input.txt");
    System.exit(-1);
}
}
```

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## Refining the problem

- Modify the program again to handle files that also contain non-numeric tokens.
  - The program should skip any such tokens.
- For example, it should produce the same output as before when given this input file:

```
308.2 hello
14.9 7.4 bad stuff 2.8

3.9 4.7 oops -15.4
:-) 2.8 @#*($&
```

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## Refining the program

```
while (scan.hasNext()) {
    if (scan.hasNextDouble()) {
        double next = scan.nextDouble();
        System.out.println("number = " + next);
    } else {
        // consume the bad token
        scan.next();
    }
}
```

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## Reading input line-by-line

- Given the following input data:

```
23 3.14 John Smith "Hello world"
45.2 19
```

- The Scanner can read it line-by-line:

```
23\t3.14 John Smith\t"Hello world"\n\t\t45.2 19\n
^
scan.nextLine()
23\t3.14 John Smith\t"Hello world"\n\t\t45.2 19\n
^
scan.nextLine()
23\t3.14 John Smith\t"Hello world"\n\t\t45.2 19\n
^
```

- The `\n` character is consumed but not returned.

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## File processing question

- Write a program that reads a text file and adds line numbers at the beginning of each line

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## Solution

```
int count = 0;
while (scan.hasNextLine()) {
    String line = scan.nextLine();
    System.out.println(count + " " + line);
    count++;
}
```

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## Problem

- Given a file with the following contents:
 

```
123 Susan 12.5 8.1 7.6 3.2
456 Brad 4.0 11.6 6.5 2.7 12
789 Jennifer 8.0 8.0 8.0 8.0 7.5
```
- Consider the task of computing hours worked by each person
- Approach:
  - Break the input into lines.
  - Break each line into tokens.

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## Scanner on strings

- A **Scanner** can tokenize a **String**, such as a line of a file.

```
Scanner <name> = new Scanner(<String>);
```

- Example:

```
String text = "1.4 3.2 hello 9 27.5";
Scanner scan = new Scanner(text);
System.out.println(scan.next()); // 1.4
System.out.println(scan.next()); // 3.2
System.out.println(scan.next()); // hello
```

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## Tokenize an entire file

- We can use string **Scanner (s)** to tokenize each line of a file:

```
Scanner scan = new Scanner(new File(<file name>));
while (scan.hasNextLine()) {
    String line = scan.nextLine();
    Scanner lineScan = new Scanner(line);
    <process this line...>
}
```

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## Example

- Example: Count the tokens on each line of a file.

```
Scanner scan = new Scanner(new File("input.txt"));
while (scan.hasNextLine()) {
    String line = scan.nextLine();
    Scanner lineScan = new Scanner(line);
    int count = 0;
    while (lineScan.hasNext()) {
        String token = lineScan.next();
        count++;
    }
    System.out.println("Line has "+count+" tokens");
}
```

| Input file input.txt:            | Output to console: |
|----------------------------------|--------------------|
| 23 3.14 John Smith "Hello world" | Line has 6 tokens  |
| 45.2 19                          | Line has 2 tokens  |

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## Opening a file for writing

- Same story as reading, we must handle exceptions:

```
public static void main(String[] args) {
    try {
        File file = new File("output.txt");
        PrintWriter output = new PrintWriter(file);
        output.println("Integer number: " + 987654);
        ...
    } catch (IOException e) {
        System.out.println("Unable to write output.txt");
        System.exit(-1);
    }
}
```

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## File output

- You can output all the same things as you would with `System.out.println`:
- Discussion so far has been limited to text files.
 

```
output.println("Double: " + fmt.format(123.456));
output.println("Integer: " + 987654);
output.println("String: " + "Hello There");
```
- Binary files store data as numbers, not characters.
- Binary files are not human readable, but more efficient.

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