

Exceptions

- Objectives - when we have completed this set of notes, you should be familiar with:
 - the purpose of exceptions
 - exception message and call stack trace
 - try-catch-finally blocks
 - propagating exceptions
 - checked and unchecked exceptions
 - throw statement and creating exceptions
 - I/O Exceptions – using try-catch blocks for File I/O
 - reading and writing text files
 - opening files in the default web browser



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Exceptions

- An **exception** is an object that describes an unusual or erroneous situation
- Exceptions are **thrown** (or raised) by a program during execution; they may be **caught** and **handled**, or they may be ignored (as we've been doing)
- A program can be separated into normal execution flow and **exception execution flow**
- An **error** is also represented as an object in Java, but usually represents an unrecoverable situation and should not be caught



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Exceptions

- If an exception is ignored by the program, a run-time error will occur and the exception and *exception message* (optional) and *call stack trace* will be printed

An example you've likely seen:

```
----jGRASP exec: java Test

Exception in thread "main" java.lang.NullPointerException
    at Test.main(Test.java:6)

----jGRASP wedge2: exit code for process is 1.
----jGRASP: operation complete.
```

- The call stack trace shows the method call trail that led to the attempted execution of the offending line of code
- See [Zero1.java](#)



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Exception Handling

- Java has a predefined set of exceptions and errors that can occur during execution
Examples:
 - `ArrayIndexOutOfBoundsException` in the `java.lang` package
 - `NumberFormatException` in the `java.lang` package
- A program can deal with an exception in one of three ways:
 - ignore it
 - handle it where it occurs
 - handle it in another place in the program



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try-catch Blocks

- To process an exception where it occurs, the statement that throws (or raises) the exception is executed within a *try block*
- A try block is usually followed by one or more *catch* blocks that specify the exception(s) to be caught and handled. A try block must be followed by a catch or finally (unless it's a try-with-resources, which will not be covered)
- When an exception occurs, processing continues at the first catch block that matches the exception type

[Zero2.java](#) [AbsoluteValue1.java](#)
[AbsoluteValue2.java](#)



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The *finally* Block

- A try block can be followed by a *finally* block
- Once a program enters the try block, the statements in the finally block are always executed [unless System.exit() is called]
 - If no exception is generated, then **after the statements in the try block complete**, the statements in the **finally** block are executed
 - If an exception occurs, control jumps to the matching **catch** block, if any, and its statements are executed, and then the statements in the **finally** block are executed
- See [Zero3.java](#) [Zero4.java](#)
[GuessNumber1.java](#) [GuessNumber2.java](#)



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Exception Propagation

- An exception can be handled at a higher level if it is not appropriate to handle it where it occurs
- An exception *propagates* up through the method calling hierarchy until it is caught and handled or if it reaches the `main` method and is still not caught, the program ends abnormally
- A try block that contains a call to a method in which an exception is thrown can be used to catch that exception
- See [Propagation.java](#) [ExceptionScope.java](#)



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Checked Exceptions

- An exception is either *checked* or *unchecked*
- A *checked exception* either must be caught by a method, or must be listed in the *throws clause* of any method that may throw or propagate it
- A throws clause is appended to the method header (e.g., throws FileNotFoundException)
- The compiler will issue an error if a checked exception is not handled appropriately



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Unchecked Exceptions

- An unchecked exception does not require you to handle it (e.g., you have likely encountered a `NullPointerException` without having try-catch blocks or a throws clause for `NullPointerException`)
- Unchecked exceptions in Java are objects of type `RuntimeException` and its descendants (see Java API for `Exception`, `RuntimeException`, etc.)
- Error objects are similar to `RuntimeException` objects in that they are unchecked
 - Errors do not require a throws clause
 - Errors should not be caught (e.g., `OutOfMemoryError`)



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The throw Statement

- You may want to explicitly throw an exception in a method
 - Often better than ignoring input / actions / etc. that your program has detected as incorrect
- Exceptions are thrown using the *throw* statement
- Usually an if statement evaluates a condition(s) to see if the exception should be thrown
- You can create your own exception if there is not an appropriate exception in the Java API
See [PolygonCreator.java](#)



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I/O Exceptions

- A *stream* is a sequence of bytes that flows from a source to a destination
- In a program, we read information from an input stream and write information to an output stream
- A program can manage multiple I/O streams simultaneously



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I/O Exceptions

- There are three standard I/O streams:
 - *standard input* – defined by `System.in`
 - *standard output* – defined by `System.out`
 - *standard error* – defined by `System.err`
- `System.in` is typically keyboard input
 - We've been using the `Scanner` class to read from `System.in`
- `System.out` and `System.err` are typically shown in a particular window on the screen
 - We use `System.out` when we execute `println` statements



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I/O Exceptions

- The `java.io` package contains many classes that allow us to define various streams with particular characteristics
- Some classes assume that the data consists of characters, which is our focus
- Others assume that the data consists of raw bytes of binary information
- Many of the I/O classes can potentially throw an `IOException` or one of its subclasses (e.g., `FileNotFoundException`)
- `IOException` is a checked exception



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I/O Exceptions

- Now we want to consider how to read and write files and how to handle I/O exceptions
- For reading from a file, we use the following:
 - `java.io.File` and `java.util.Scanner`
- For writing to a file, we use the following:
 - `java.io.PrintWriter`



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Reading from a File

- To read from a text file, you can create an instance of the File class in java.io, using the name of the file to be read (a String)
- You can then instantiate a Scanner object using the File object that you created
- At that point, you can use the Scanner methods to read the file (and these should be familiar to you):
 - The next method reads a "token"
 - The nextLine method reads a whole line
 - The hasNext and hasNextLine are also useful (see API documentation for more information and methods)



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Reading from a File

- The Scanner class has a constructor that accepts a File object as a parameter (see Java API), which throws FileNotFoundException, a subclass of IOException, so you can catch either
- FileNotFoundException is a checked exception, so you have to do one of two things ...
 - Specify throws FileNotFoundException in the method header
 - Handle the exception with a try-catch; good practice to close the Scanner object for a file (consider finally block)
- See [ReadLines1.java](#) [ReadLines2.java](#)
[ReadLines3.java](#) [ReadLines3.java](#)



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Writing to a File

- Instantiate a `PrintWriter` object using the file name (a `String`)
 - The `PrintWriter` constructor throws `FileNotFoundException`
- `PrintWriter` has methods similar to `System.out`
 - `print`: writes a specified `String` to a file
 - `println`: writes a specified `String` and a new line to a file
 - **When writing is completed, invoke the `close()` method on the `PrintWriter` object to flush buffer; otherwise, nothing may be written to the file!**
- See [WriteLines1.java](#) [WriteLines2.java](#)
[WriteReadRandom.java](#)



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Writing HTML to a File

- Similar to writing plain text with `PrintWriter`
- Add HTML tags to the text (here are a few)
 - Heading `<h1> . . . </h1>`
 - Paragraph `<p> . . . </p>`
 - Line break `
`
 - Bold ` . . . `
 - Pre-format `<pre> . . . </pre>`
 - Font color ` . . . `
- Opening HTML file in default browser
- See [WriteLinesHTML.java](#)
[WriteRandomHTML.java](#)



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