COMP 202 Exceptions

CONTENTS:
- Exceptions and Errors
- The try-catch statement
- The try-catch-finally statement
- Exception propagation
Exceptions

• An exception is an object that describes an unusual or erroneous situation
  – division by zero
  – reading the wrong data type from a Scanner
  – accessing a non existing array-element
    • out of bound
  – accessing a null object
  – …
Exceptions

• When such an unusual situation occurs
  – the program *throws* an exception
  – it does not continue with the next statement in the program
  – so far, the program actually terminates

• Instead of letting the program terminate
  – an exception can be *caught* and *handled* by another part of the program
  – that is, the programmer writes special code that is executed whenever an exception is thrown

• A program can therefore be separated into a normal execution flow and an *exception execution flow*

• An *error* is also represented as an object in Java, but usually represents a unrecoverable situation and should not be caught
Exceptions

- Exceptions:
  - java.lang.ArrayIndexOutOfBoundsException
  - java.lang.StringIndexOutOfBoundsException
  - java.lang.NullPointerException

- Errors:
  - java.lang.OutOfMemoryError
  - java.lang.ClassFormatException
  - java.lang.InternalError
  - java.lang.VirtualMachineError
Exception Handling

• If an exception is ignored by the program, the program will terminate and produce an appropriate message

• The message includes a call stack trace that indicates on which line the exception occurred

• The call stack trace also shows the method call trail that lead to the execution of the offending line
public class Zero
{
    // Deliberately divides by zero to produce an exception.
    public static void main (String[] args)
    {
        int numerator = 10;
        int denominator = 0;

        System.out.println (numerator / denominator);
        System.out.println ("Will this line be printed?");
    }
}
The `try` Statement

- To process an exception when it occurs, the line that throws the exception is executed within a `try block`.

- A `try` block is followed by one or more `catch` clauses, which contain code to process an exception.

- Each `catch` clause has an associated exception type.

- When an exception occurs, processing continues at the first `catch` clause that matches the exception type.
Using `try-catch`

General format:

```
try {
    // code which may throw an exception
} catch(AException ae) {
    // control goes here if an AException occurs
} catch(BException be) {
    // control goes here if a BException occurs
} ...etc
```
ZeroException

```java
public class Zero {
    //-----------------------------------------------------------
    // Deliberately divides by zero to produce an exception.
    //-----------------------------------------------------------
    public static void main (String[] args) {
        int numerator = 10;
        int denominator = 0;

        try {
            System.out.println (numerator / denominator);
        } catch (ArithmeticException ex) {
            System.out.println("Arithmetic error: "+ex.getMessage());
        }
        System.out.println ("Will this line be printed?");
    }
}
```
The *finally* Clause

- A try statement can have an optional clause designated by the reserved word `finally`.
- If no exception is generated, the statements in the `finally` clause are executed after the statements in the try block complete.
- Also, if an exception is generated, the statements in the `finally` clause are executed after the statements in the appropriate `catch` clause complete.
Using `try-catch-finally`

General format:

```java
try {
    // code which may throw an exception
} catch (AException ae) {
    // control goes here if an AException occurs
} catch (BException be) {
    // control goes here if a BException occurs
} finally {
    // this code is always executed before
    // control flow leaves the try or any catch
}
```
Exception Propagation

• If it is not appropriate to handle the exception where it occurs, it can be handled at a higher level

• Exceptions *propagate* up through the method calling hierarchy until they are caught and handled or until they reach the outermost level

• A try block that contains a call to a method in which an exception is thrown can be used to catch that exception
public class Zero2
{
    //----------------------------------------------------------------------------------
    // Deliberately divides by zero to produce an exception.
    //----------------------------------------------------------------------------------
    public static void main (String[] args)
    {
        int numerator = 10;
        int denominator = 0;

        divide(numerator, denominator);

        System.out.println ("Will this line of main be printed?");
    }

    public static void divide (int num, int den)
    {
        System.out.println (num / den);
        System.out.println ("Will this line of divide be printed?");
    }
}
Zero2Exception.java

```java
public class Zero2 {
    //-----------------------------------------------------------
    // Deliberately divides by zero to produce an exception.
    //-----------------------------------------------------------
    public static void main (String[] args) {
        int numerator = 10;
        int denominator = 0;

        try {
            divide(numerator, denominator);
        }
        catch (ArithmeticException ex) {
            System.out.println("Arithmetic Error: "+ex.getMessage());
        }
        System.out.println ("Will this line of main be printed?");

        public static void divide (int num, int den) {
            System.out.println (num / den);
            System.out.println ("Will this line of divide by printed?");
        }
    }
}
```
Three ways to handle Exceptions

- ignore the exception
  - the program terminates

- handle the exception where it occurs
  - the exception handling code resides in the method that throws the exception

- handle the exception at another place in the program
  - the exception handling code resides somewhere in the calling hierarchy (method calls method that calls method… that calls method that throws the exception)
public class WildernessIndex
{
    static public void main (String[] args)
    {
        WorldZoom wildIndex = new WorldZoom();

        System.out.println("Picking a country...");
        wildIndex.theUS();

        System.out.println("\nPicking another country...");
        wildIndex.canada();

        System.out.println("\nDone.");
    }
}
class WorldZoom {
    public void canada() {
        System.out.println("Zooming in to Canada.");
        try {
            quebec();
        } catch (ArithmeticException problem) {
            System.out.println();
            System.out.println("The exception message is: " + problem.getMessage());
            System.out.println();
            System.out.println("The call stack trace:");
            problem.printStackTrace();
            System.out.println();
        }
        System.out.println("Zooming out of Canada.");
    }
}
public void quebec() {
    System.out.println("Zooming in to Quebec.");
    montreal();
    System.out.println("Zooming out of quebec.");
}

public void montreal(){
    int numPeople = 3000000, numBears = 0;

    System.out.println("Zooming in to Montreal.");
    int result = numPeople / numBears;
    System.out.println("The wilderness index is: " + result);
    System.out.println("Zooming out of Montreal.");
}

public void alaska() {
    System.out.println("Zooming in to Alaska.");
    kodiak();
    System.out.println("Zooming out of Alaska.");
}

public void kodiak(){
    int numPeople = 13000, numBears = 3000;

    System.out.println("Zooming in to kodiak island.");
    int result = numPeople / numBears;
    System.out.println("The wilderness index is: " + result);
    System.out.println("Zooming out of kodiak island.");
}
public void theUS() {
    System.out.println("Zooming in to the US.");

    try {
        alaska();
    } catch (ArithmeticException problem) {
        System.out.println();
        System.out.println("The exception message is: " +
                          problem.getMessage());
        System.out.println();
        System.out.println("The call stack trace:");
        problem.printStackTrace();
        System.out.println();
    }

    System.out.println("Zooming out of the US.");
}
}
Checked Exceptions

- An exception is either *checked* or *unchecked*
- So far unchecked exceptions
  - they are the default handling procedure
  - can but do not need to be caught or propagated but
  - if not caught anywhere then program simply terminates
- A checked exception
  - must be caught within within a try/catch block within the method in which it occurs
  - can be propagated to the outer method
    - but then the method that throws the exception must declare this
    - A *throws* clause must be appended to the header of the method
    - We will see the throws clause when we handle files
  - The compiler will complain if a checked exception is not handled or declared appropriately