## Exceptions - Chapter 11

- Exceptions are errors or unexpected actions.
- Some examples are:
  - IndexOutOfBoundsException
  - NullPointerException
  - NumberFormatException
  - ArithmeticException
  - FileIOException
- In Java we can "catch" them and try to recover.

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## Robust Programs

- A robust program deals gracefully with unexpected input (among other things).

```
int myData = Console.in.readInt();
```

- How can we make this more robust? More specifically, what happens if the user doesn't enter an integer?

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```
class Status {
  boolean flag;
}
```

```
Status status = new Status();
int myData = Console.in.readInt(status);
if (!status.flag) {
  // put error handling code here
}
```

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## Problems with this approach

- Had to modify readInt().
- Needed to declare status in our code.
- Needed to test **`status`** even though we "expect" it to always be true.
- Even worse, what if the preceding code was inside another method?

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This example just passes the status up the line, returning a bogus value to keep the compiler happy.

```
int processInput(..., Status status) {
  ...
  int myData = Console.in.readInt(status);
  if (!status.flag) {
             // have to return something
    return 0;// assume return value is ignored
  }
  // go on with normal processing
  ...
}
```

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## try-catch

- Exception handling is language support for the previous scenario.
- When something goes wrong an exception is "thrown".
- The code that wants to deal with the exception can "catch" it.

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```
try {
  // some code here that might throw an exception
}
catch (ExceptionType Identifier) {
  // some code here to recover from the problem
}
```

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```
int myData;
try {
  myData = Console.in.readInt();
}
catch (NumberFormatException e) {
  // some code here to recover from the problem
}


int processInput(...) {
  ...
  int myData = Console.in.readInt();
  // go on with normal processing
}
```

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```
import tio.*;
public class ExceptionExample {
  public static void main(String[] args) {
    int aNumber = 0;
    boolean success = false;
    String inputString = "";
    System.out.println("Type an integer.");
    while (!success) {
      try {
        aNumber = Console.in.readInt();
        success = true;
      }
      catch (NumberFormatException exception) {
        inputString = Console.in.readWord();
        System.out.println(inputString +
              " is not an integer. Try again!");
      }
    }
    System.out.println("You typed " + aNumber);
    // continue with code to process aNumber
  }
}
```

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```
import java.io.*;

class BinaryInput {
  public static void main(String[] args)
       throws IOException
  {
    DataInputStream input = null;
    if (args.length != 1) {
      System.out.println("Usage: " +
          "java BinaryInput filename");
      System.exit(1);
    }
    try {
      input = new DataInputStream(
                  new FileInputStream(args[0]));
    }
    catch (IOException e) {
      System.out.println("Could not open " + args[0]);
      System.out.println(e);
      System.exit(1);
    }
```

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```
    // count is used to print 4 values per line
    int count = 0;
    try {
      while (true) {
        int myData = input.readInt();
        count++;
        System.out.print(myData + " ");
        // print a newline every 4th value
        if (count % 4 == 0)
          System.out.println();
      }
    }
    catch (EOFException e)
    {
      // just catch the exception and discard it
    }
    // add a newline after the last partial line
    // if necessary
    if (count % 4 != 0)
      System.out.println();
  }
}
```

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```
// ExceptionExampleTwo.java - show control flow when
//   an exception occurs during nested method calls
import tio.*;

class ExceptionExampleTwo {

  public static void main(String[] args) {
    int x = 0;
    System.out.println("main starting");
    try {
      x = callOne();
      System.out.println("callOne OK x = " + x);
    }
    catch (ArithmeticException e) {
      System.out.println("callOne not OK: " + e);
      x = -1;
    }
    System.out.println("main exiting x = " + x);
  }
```

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```
  static int callOne() {
    System.out.println("callOne starting");
    int result = callTwo();
    System.out.println("callOne returning result = "
                       + result);
    return result;
  }
  static int callTwo() {
    int num = 0;
    System.out.println("type a number");
    int input = Console.in.readInt();
    num = 1000 / input;
    System.out.println("callTwo returning num = "
                       + num);
    return num;
  }
}
```

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## Nested Exceptions

- Run ExceptionExampleTwo first giving it 10 as the input and the give it 0.

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```
// TwoCatchExample.java - use two catch clauses
    ...
    while (!success) {
      try {
        aNumber = Console.in.readInt();
        success = true;
        System.out.println("You typed " + aNumber);
      }
      catch (NumberFormatException exception) {
        inputString = Console.in.readWord();
        System.out.println(inputString +
              " is not an integer. Try again!");
      }
      catch (tio.ReadException exception) {
        System.out.println(
              "Continuing with default value 0.");
        aNumber = 0;
        success = true;
      }
    }
    // continue with code to process a_number
```

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```
// BinaryInput2.java - read some integers from
//     a binary file
import java.io.*;

class BinaryInput2 {
  public static int readBinaryInput(String filename,
                                     int howMany)
       throws IOException
  {
    DataInputStream input = null;
    try {
      input = new DataInputStream(
                  new FileInputStream(filename));
    }
    catch (IOException e) {
      System.out.println("Could not open " +filename);
      System.out.println(e);
      throw e;
    }
```

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```
    int count = 0;
    try {
      while (count < howMany) {
        int myData = input.readInt();
        System.out.print(myData + " ");
        // print a newline every 4th value
        if (++count % 4 == 0)
          System.out.println();
       }
    }
    catch (EOFException e) { /* ignore */}
    finally {
      if (count % 4 != 0)
        System.out.println();
      if (input != null)
        input.close();
    }
    return count;
  }
}
```

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## Throwing Exceptions

- Some exceptions are thrown "automatically" by the Java Virtual Machine. E.g. IndexOutOfBoundsException
- You can also throw them yourself.

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```
public class Counter {
  //constructors
  public Counter() {}

  public Counter(int v) {
    if (v < 0 || v >= MAX)
      throw new Exception("Invalid intial value.");
    else
      value = v % MAX;
...
```

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## The throws clause

- When do you need a throws?
- There are two types of exceptions in Java
  - checked exceptions, and
  - unchecked exceptions.
- Checked exceptions require a throws clause whenever they might be thrown.
- Unchecked exceptions are things like NullPointerException, and IndexOutOfBoundsException.

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## Checked vs Unchecked

- Unchecked exceptions are exceptions that are instances of java.lang.RuntimeException, java.lang.Error, or one of their subclasses.
- Everything else is a checked exception.

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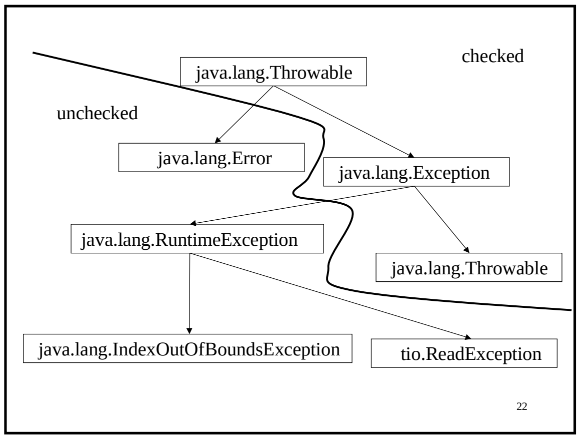
checked
java.lang.Throwable
unchecked
java.lang.Error
java.lang.Exception
java.lang.RuntimeException
java.lang.Throwable
java.lang.IndexOutOfBoundsException
tio.ReadException
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