Java Exception Handling

Handling errors using Java's exception handling mechanism

Approaches For Dealing With Error Conditions

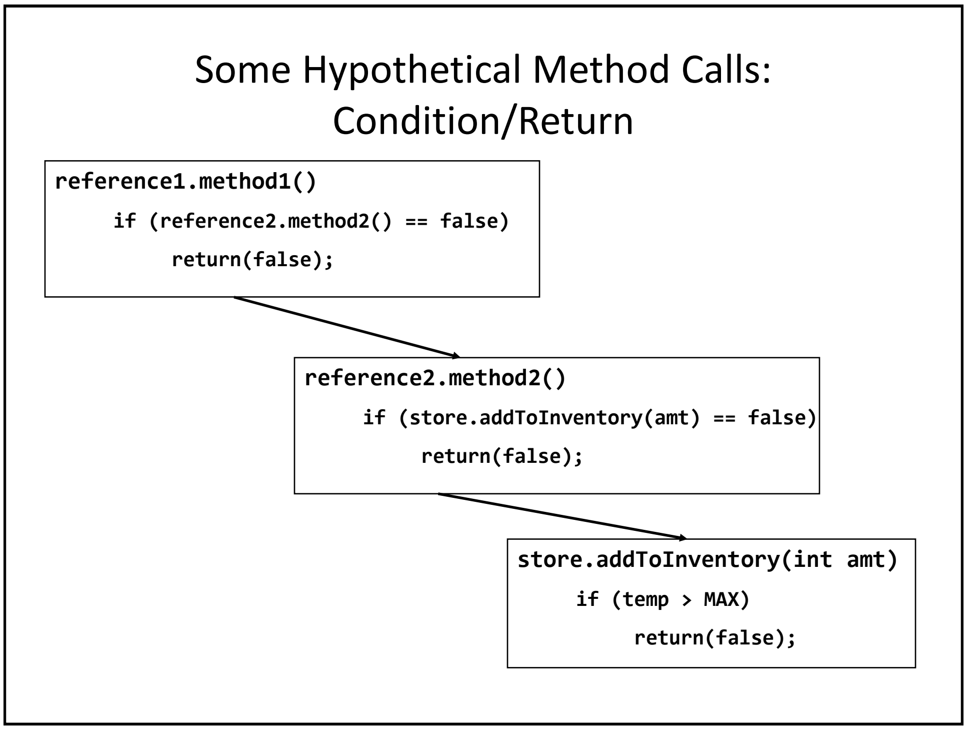
- Use branches/decision making and return values
- Use Java's exception handling mechanism

Class Inventory: An Earlier Example

```
public class Inventory
{
    public final int MIN = 0;
    public     final int MAX = 100;
    public final int CRITICAL = 10;
    public boolean add(int amount)
    {
       int temp;
        temp = stockLevel + amount;
        if (temp > MAX)
        {
            System.out.print("Adding " + amount + " item will
                              cause stock ");
            System.out.println("to become greater than " + MAX +
                               " units (overstock)");
            return(false);
        }
```

Class Inventory: An Earlier Example (2)

```
         else
        {
            stockLevel = stockLevel + amount;
           return(true);
        }
    } // End of method add()
    ...
```

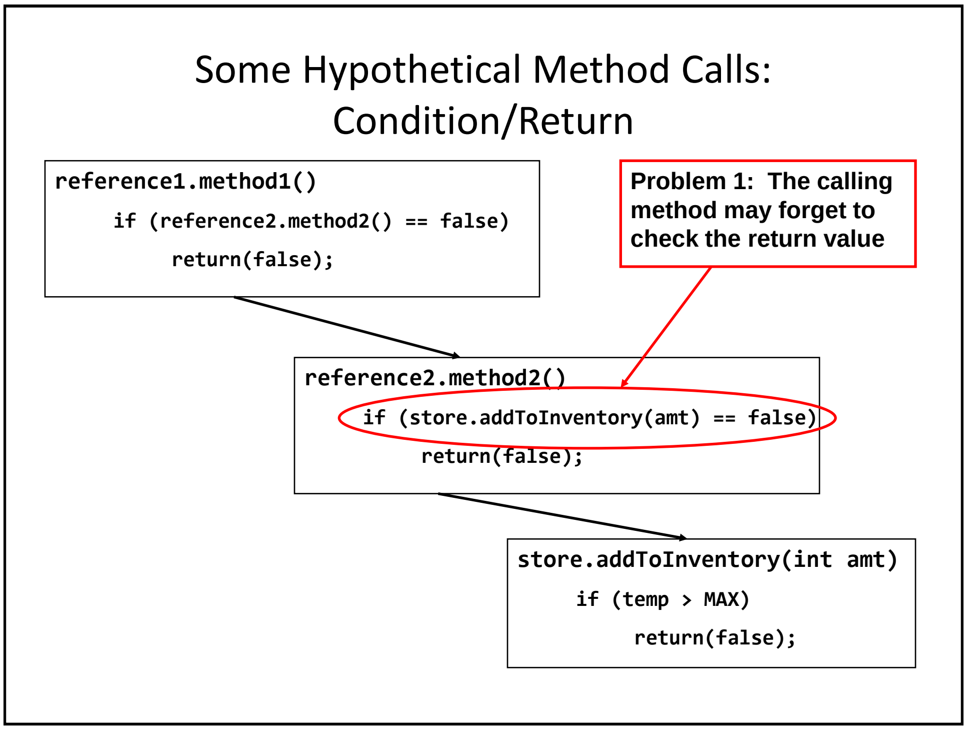


Some Hypothetical Method Calls: Condition/Return

```
reference1.method1()
     if (reference2.method2() == false)
          return(false);
```

```
reference2.method2()
     if (store.addToInventory(amt) == false)
          return(false);
```

```
store.addToInventory(int amt)
     if (temp > MAX)
          return(false);
```



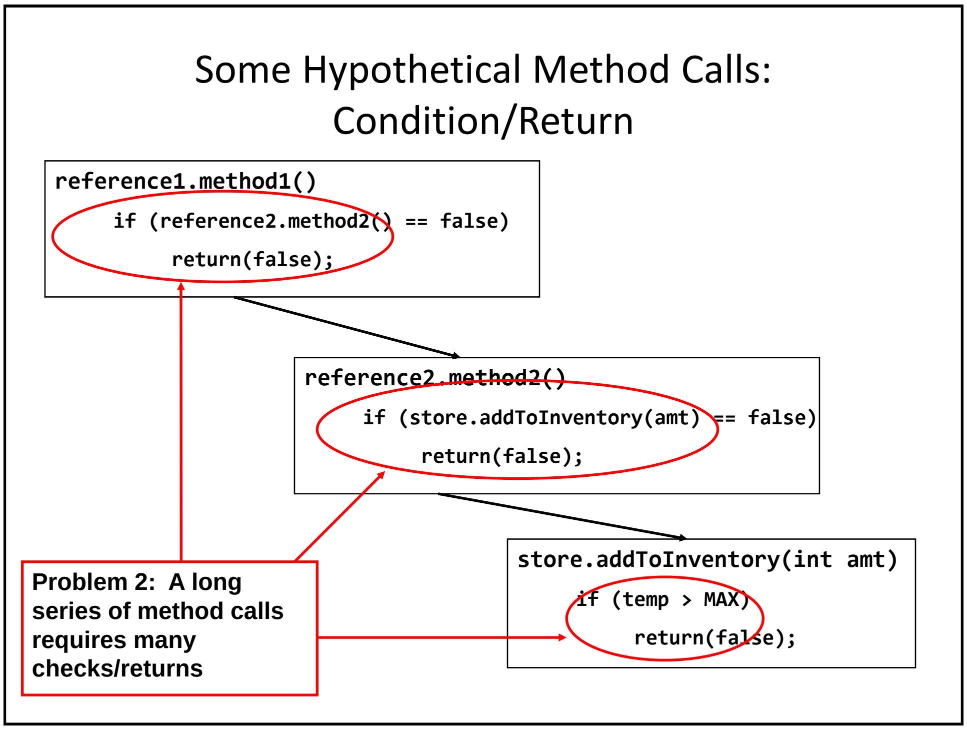
Some Hypothetical Method Calls: Condition/Return

```
reference1.method1()
     if (reference2.method2() == false)
          return(false);
```

Problem 1: The calling method may forget to check the return value

```
reference2.method2()
     if (store.addToInventory(amt) == false)
          return(false);
```

```
store.addToInventory(int amt)
     if (temp > MAX)
          return(false);
```



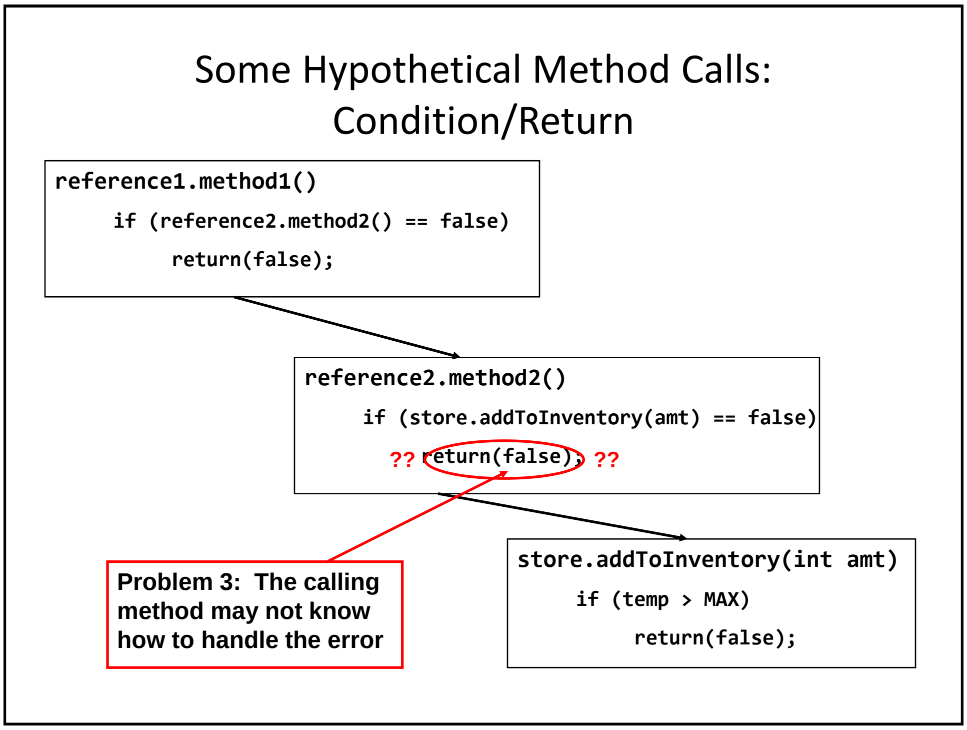
Some Hypothetical Method Calls: Condition/Return

```
reference1.method1()
     if (reference2.method2() == false)
          return(false);
```

```
reference2.method2()
     if (store.addToInventory(amt) == false)
          return(false);
```

```
store.addToInventory(int amt)
     if (temp > MAX)
          return(false);
```

Problem 2: A long series of method calls requires many checks/returns



Some Hypothetical Method Calls: Condition/Return

```
reference1.method1()
     if (reference2.method2() == false)
          return(false);
```

```
reference2.method2()
     if (store.addToInventory(amt) == false)
       ?? return(false); ??
```

```
store.addToInventory(int amt)
     if (temp > MAX)
          return(false);
```

Problem 3: The calling method may not know how to handle the error

Approaches For Dealing With Error Conditions

- Use branches/decision making constructs and return values
- Use Java's exception handling mechanism

Handling Exceptions

Format:

```
try
{
    // Code that may cause an error/exception to occur
}
catch (ExceptionType identifier)
{
    // Code to handle the exception
}
```

Handling Exceptions: Reading Input

Location of the online example:
`/home/233/examples/exceptions/handlingExceptions/inputExample`

```
public class Driver {
    public static void main (String [] args)
    {
        BufferedReader stringInput;
        InputStreamReader characterInput;
        String s;
        int num;
        characterInput = new InputStreamReader(System.in);
        stringInput = new BufferedReader(characterInput);
```

Handling Exceptions: Reading Input (2)

```
        try
        {
            System.out.print("Type an integer: ");
            s = stringInput.readLine();
            System.out.println("You typed in..." + s);
            num = Integer.parseInt (s);
            System.out.println("Converted to an integer..."
                                + num);
        }
        catch (IOException e)
        {
            System.out.println(e);
        }
        catch (NumberFormatException e)
        {
            ...
        }
    }
}
```

Handling Exceptions: Where The Exceptions Occur

The first exception can occur here

```
try
{
     System.out.print("Type an integer: ");
      s = stringInput.readLine();
      System.out.println("You typed in..." + s);
      num = Integer.parseInt (s);
      System.out.println("Converted to an integer..."
                          + num);
 }
```

Handling Exceptions: Result Of Calling BufferedReader.ReadLine()

```
try
{
     System.out.print("Type an integer: ");
      s = stringInput.readLine();
      System.out.println("You typed in..." + s);
      num = Integer.parseInt (s);
      System.out.println("Converted to an integer..."
                          + num);
 }
```

Where The Exceptions Occur In Class BufferedReader

- For online documentation for this class go to:
  - http://docs.oracle.com/javase/7/docs/api/java/io/BufferedReader.html

```
public class BufferedReader
{
    public BufferedReader(Reader in);
    public BufferedReader(Reader in, int sz);
    public String readLine() throws IOException;
      ...
}
```

Handling Exceptions: Result Of Calling Integer.ParseInt ()

```
try
{
     System.out.print("Type an integer: ");
      s = stringInput.readLine();
      System.out.println("You typed in..." + s);
      num = Integer.parseInt (s);
      System.out.println("Converted to an integer..."
                         + num);
 }
```

The second exception can occur here

Where The Exceptions Occur In Class Integer

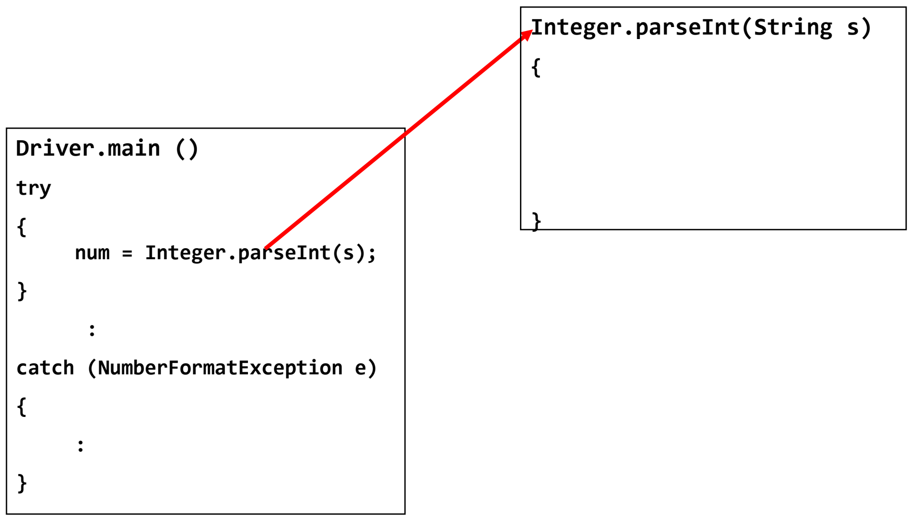
- For online documentation for this class go to:
  - http://docs.oracle.com/javase/7/docs/api/java/lang/Integer.html

```
public class Integer
{
    public Integer(int value);
    public Integer(String s) throws NumberFormatException;
      ...
    public static int parseInt(String s) throws
                                NumberFormatException;
      ...
}
```

Handling Exceptions: The Details

```
        try
        {
            System.out.print("Type an integer: ");
            s = stringInput.readLine();
            System.out.println("You typed in..." + s);
            num = Integer.parseInt (s);
            System.out.println("Converted to an integer..."
                                  + num);
         }
         catch (IOException e)
         {
            System.out.println(e);
         }
         catch (NumberFormatException e)
         {
              ...
         }
    }
}
```

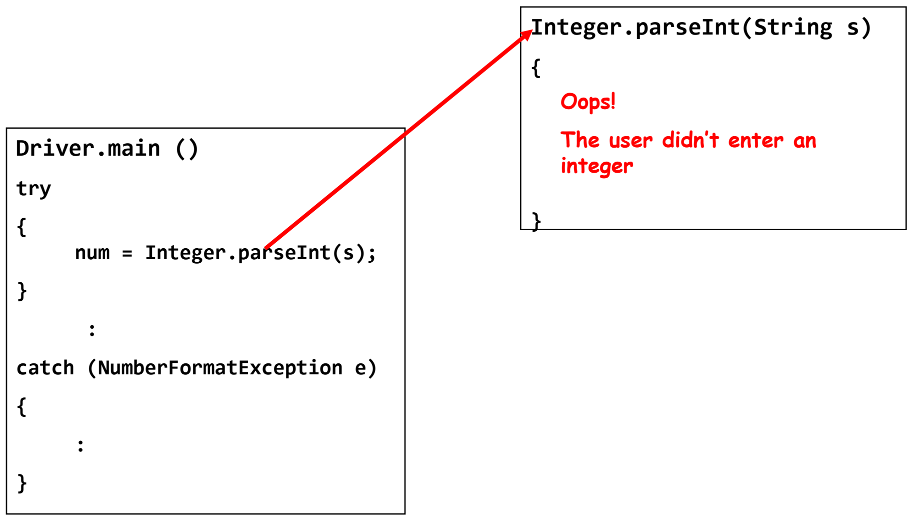
Handling Exceptions: Tracing The Example



```
Driver.main ()
try
{
     num = Integer.parseInt(s);
}
      :
catch (NumberFormatException e)
{
     :
}
```

```
Integer.parseInt(String s)
{



}
```

Handling Exceptions: Tracing The Example



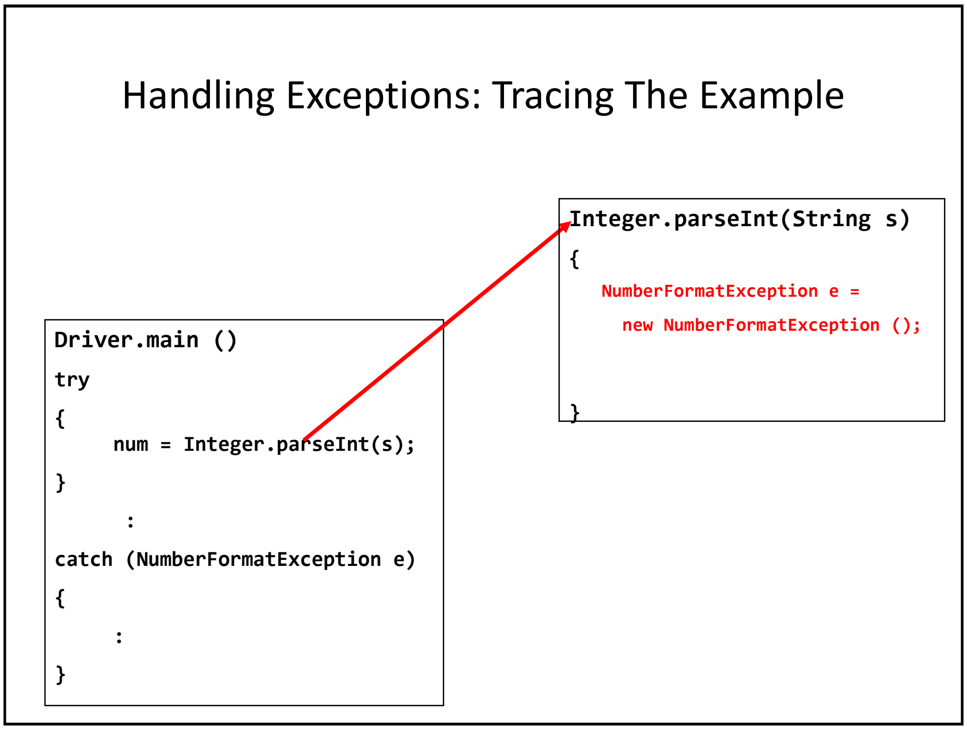
```
Driver.main ()
try
{
     num = Integer.parseInt(s);
}
      :
catch (NumberFormatException e)
{
     :
}
```

```
Integer.parseInt(String s)
{
```

Oops!

The user didn't enter an integer

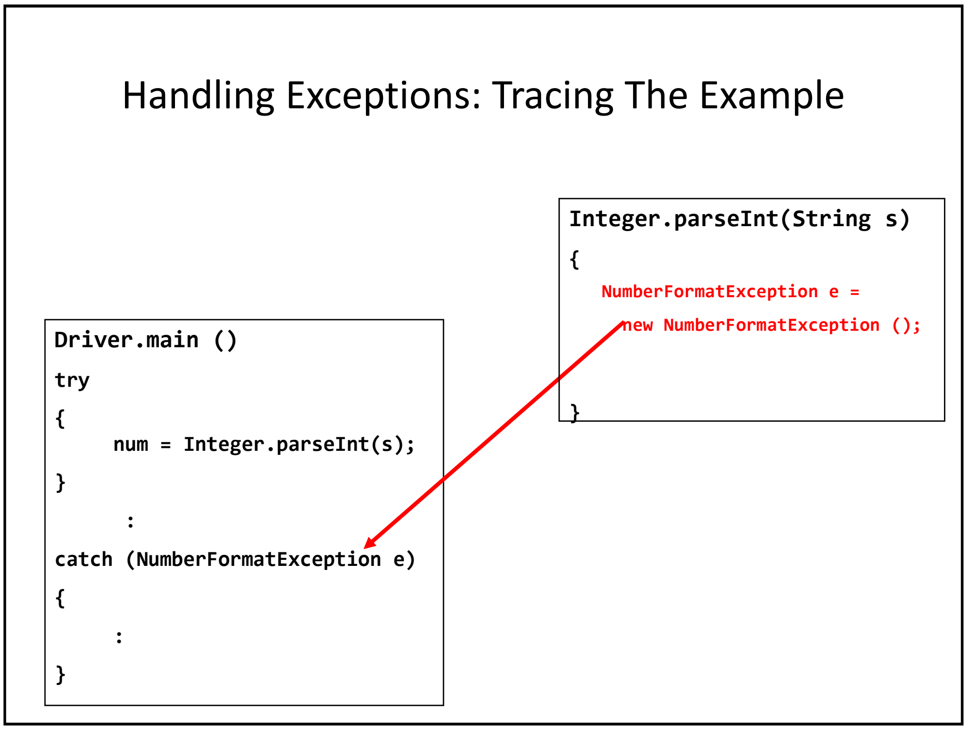
```
}
```



Handling Exceptions: Tracing The Example

```
Driver.main ()
try
{
        num = Integer.parseInt(s);
}
         :
catch (NumberFormatException e)
{
        :
}
```

```
Integer.parseInt(String s)
{
    NumberFormatException e =
      new NumberFormatException ();


}
```



Handling Exceptions: Tracing The Example

```
Driver.main ()
try
{
        num = Integer.parseInt(s);
}
         :
catch (NumberFormatException e)
{
        :
}
```

```
Integer.parseInt(String s)
{
    NumberFormatException e =
      new NumberFormatException ();


}
```

Handling Exceptions: Tracing The Example

```
Integer.parseInt(String s)
{
   NumberFormatException e =
     new NumberFormatException ();


}
```

```
Driver.main ()
try
{
     num = Integer.parseInt(s);
}
      :
catch (NumberFormatException e)
{
  Exception must be dealt
  with here
}
```

Handling Exceptions: Catching The Exception

```
          catch (NumberFormatException e)
          {
               ...
          }
     }
}
```

Catching The Exception: Error Messages

```
        catch (NumberFormatException e)
         {
             System.out.println(“You entered a non-integer
                                       value.”);
            System.out.println(e.getMessage());
            System.out.println(e);
            e.printStackTrace();
        }
    }
}
```

Catching The Exception: Error Messages

```
        catch (NumberFormatException e)
         {
             System.out.println(“You entered a non-integer
                                       value.”);
            System.out.println(e.getMessage());
            System.out.println(e);
            e.printStackTrace();
        }
    }
}
```

```
For input string: "james tam"
```

```
java.lang.NumberFormatException:
For input string: "james tam"
```

```
java.lang.NumberFormatException: For input string: "james tam"
    at java.lang.NumberFormatException.forInputString(NumberFormatException.java:48)
    at java.lang.Integer.parseInt(Integer.java:426)
    at java.lang.Integer.parseInt(Integer.java:476)
    at Driver.main(Driver.java:39)
```

Avoid Squelching Your Exceptions

```
try
{
    s = stringInput.readLine();
    num = Integer.parseInt (s);
}
catch (IOException e)
{
    System.out.println(e);
}
catch (NumberFormatException e)
{
    // Do nothing here but set up the try-catch block to
    // bypass the "annoying" compiler error
}
```

Avoid Squelching Your Exceptions

```
try
{
    s = stringInput.readLine();
    num = Integer.parseInt (s);
}
catch (IOException e)
{
    System.out.println(e);
}
catch (NumberFormatException e)
{
    // Do nothing here but set up the try-catch block to
    // bypass the "annoying" compiler error
}
```

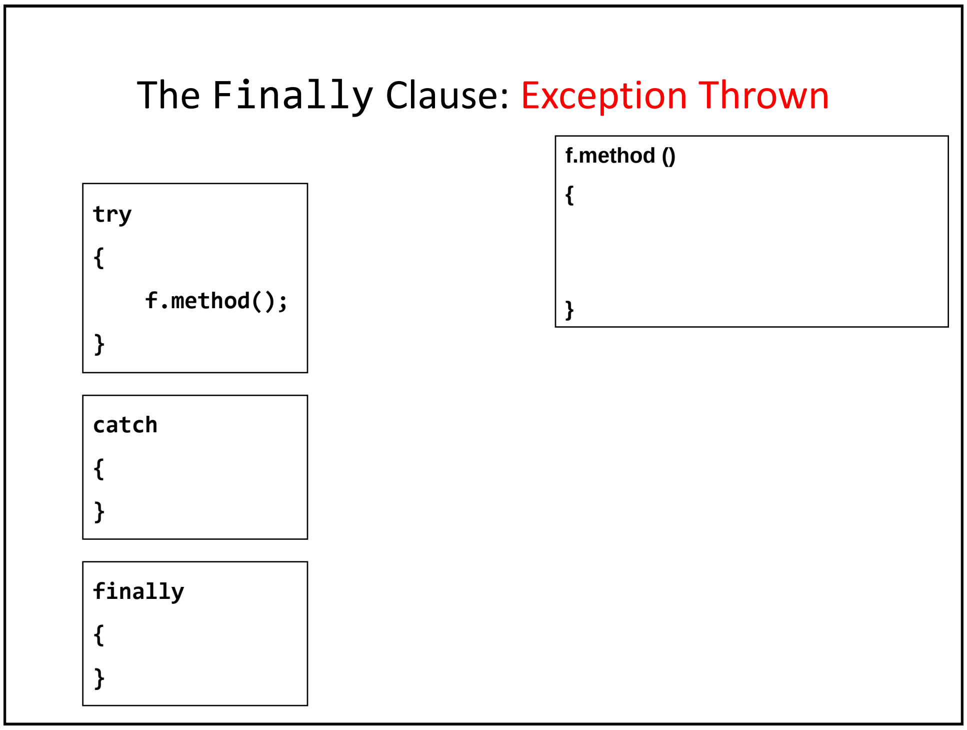
NO!

Avoid Squelching Your Exceptions

```
try
{
    s = stringInput.readLine();
    num = Integer.parseInt (s);
}
catch (IOException e)
{
   System.out.println(e);
}
catch (NumberFormatException e)
{
   // Minimal but still somewhat useful response
   System.out.println(“A non integer value entered
                       instead of an integer”);
}
```

The `Finally` Clause

- An additional part of Java’s exception handling model (`try`-`catch`-*`finally`*).
- Used to enclose statements that must always be executed whether or not an exception occurs.



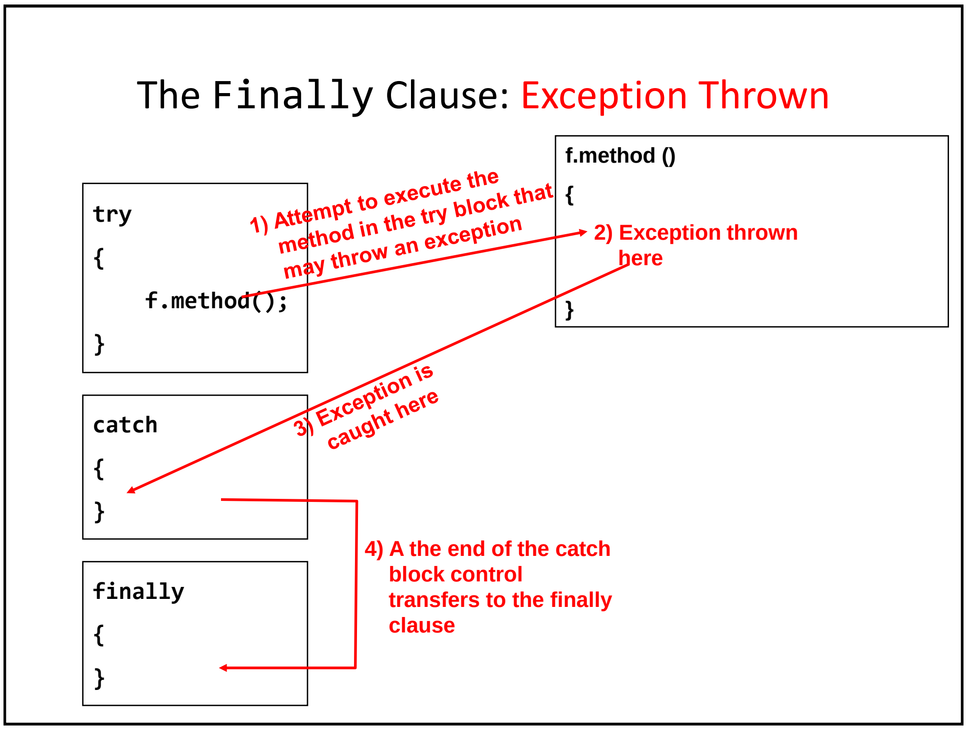
The Finally Clause: Exception Thrown

```
try
{
    f.method();
}
```

```
catch
{
}
```

```
finally
{
}
```

```
f.method ()
{

}
```



The Finally Clause: Exception Thrown

```
try
{
    f.method();
}
```

```
catch
{
}
```

```
finally
{
}
```

```
f.method ()
{

}
```

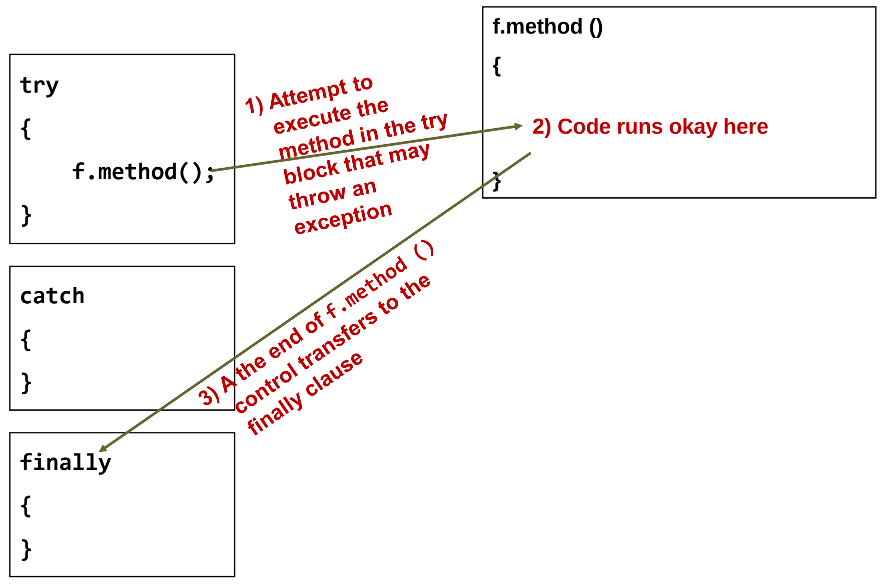
1) Attempt to execute the method in the try block that may throw an exception

2) Exception thrown here

3) Exception is caught here

4) A the end of the catch block control transfers to the finally clause

The Finally Clause: No Exception Thrown


try
{
f.method();
}
catch
{
}
finally
{
}
f.method ()
{
}
1) Attempt to execute the method in the try block that may throw an exception
2) Code runs okay here
3) At the end of f.method () control transfers to the finally clause

Try-Catch-Finally: An Example

Location of the online example:
`/home/233/examples/exceptions/handlingExceptions/tryCatchFinallyExample`

```
public class Driver
{
    public static void main (String [] args)
    {
        TCFExample eg = new TCFExample ();
        eg.method();
    }
}
```

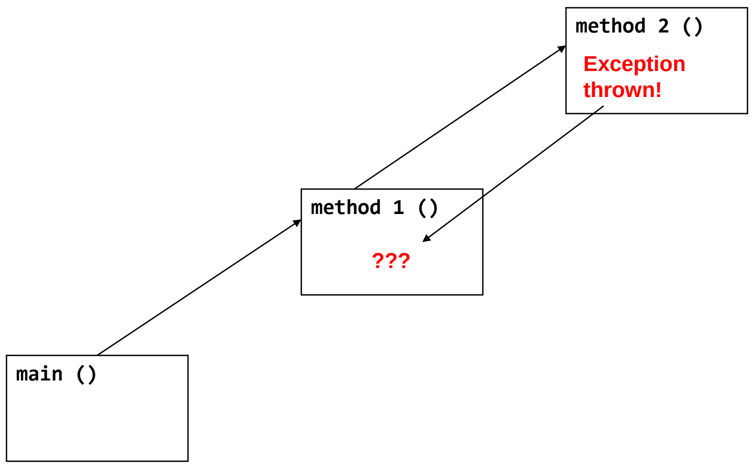
Try-Catch-Finally: An Example (2)

```
public class TCFExample
{
  public void method ()
    {
        BufferedReader br;
        String s;
        int num;
        try
        {
            System.out.print("Type in an integer: ");
            br = new BufferedReader(new
                   InputStreamReader(System.in));
            s = br.readLine();
            num = Integer.parseInt(s);
            return;
        }
```

Try-Catch-Finally: An Example (3)

```
        catch (IOException e)
        {
            e.printStackTrace();
            return;
        }
        catch (NumberFormatException e)
        {
            e.printStackTrace ();
            return;
        }
        finally
        {
            System.out.println("<<<This code will always
                                execute>>>");
            return;
        }
    }
}
```

When The Caller Can't Handle The Exceptions



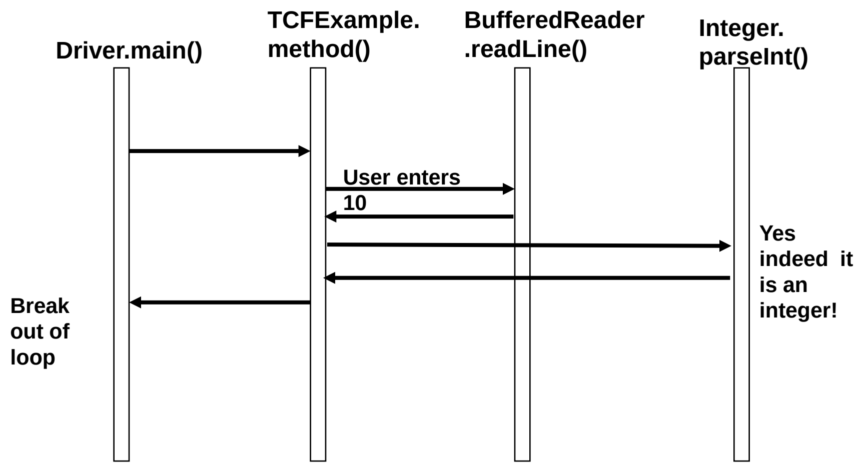
When The Caller Can't Handle The Exceptions: An Example

Location of the online example:

`/home/233/examples/exceptions/handlingExceptions/delegatingExceptions`

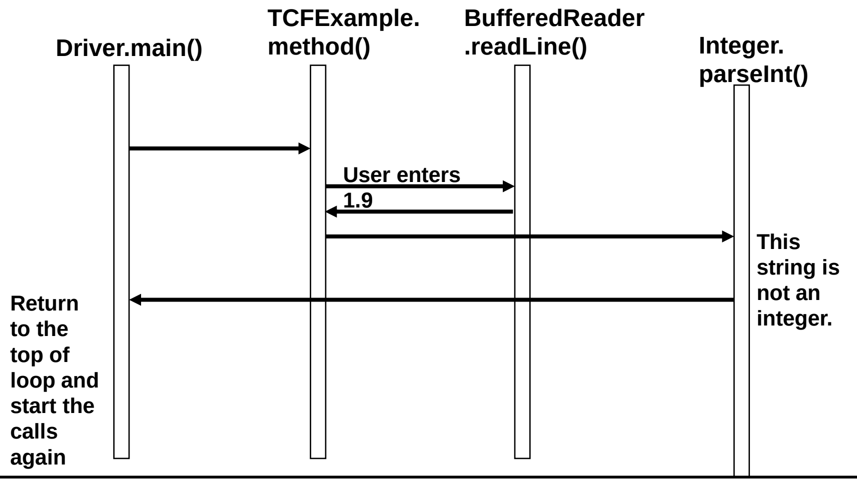
When The Caller Can't Handle The Exceptions: An Example (2)

•Tracing the method calls when *no exception* occurs:



When The Caller Can't Handle The Exceptions: An Example (3)

•Tracing the method calls when an *exception does occur*:


Driver.main()
TCFExample. method()
BufferedReader .readLine()
Integer. parseInt()
User enters 1.9
This string is not an integer.
Return to the top of loop and start the calls again

When The Caller Can't Handle The Exceptions: An Example (4)

```
public class Driver
{
    public static void main (String [] args)
    {
        TCExample eg = new TCExample ();
        boolean inputOkay = true;
```

When The Caller Can't Handle The Exceptions: An Example (5)

```
        do {
            try {
                eg.method();
                inputOkay = true;
            }
            catch (IOException e) {
                e.printStackTrace();
            }
            catch (NumberFormatException e) {
                inputOkay = false;
                System.out.println("Please enter a whole
                                    number.");
            }
        } while(inputOkay == false);
    }  // End of main
} // End of Driver class
```

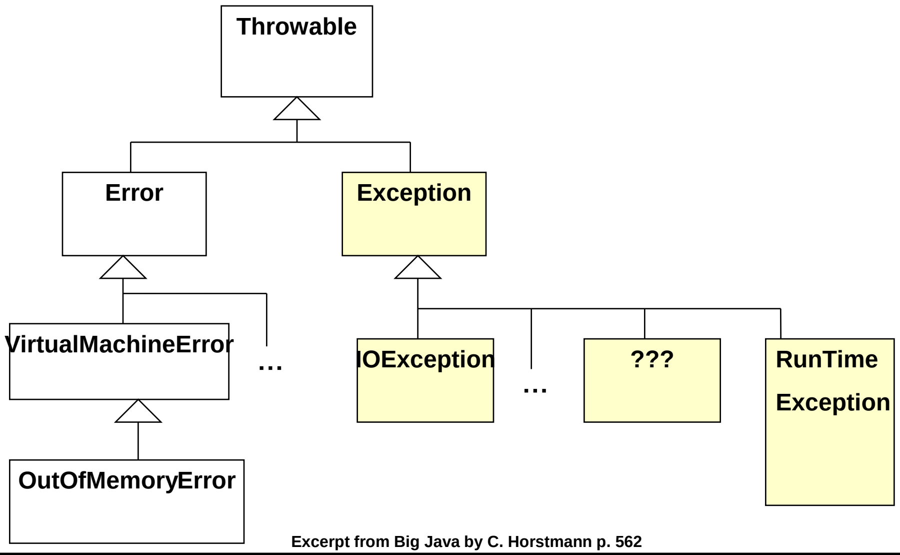
When The Caller Can't Handle The Exceptions: An Example (6)

```
public class TCExample
{

   public void method () throws IOException,
                                NumberFormatException
   {
       BufferedReader br;
       String s;
       int num;

        System.out.print("Type in an integer: ");
        br = new BufferedReader(new
          InputStreamReader(System.in));
        s = br.readLine();
        num = Integer.parseInt(s);
    }
}
```

When The `Driver.Main ()` Method Can't Handle The Exception

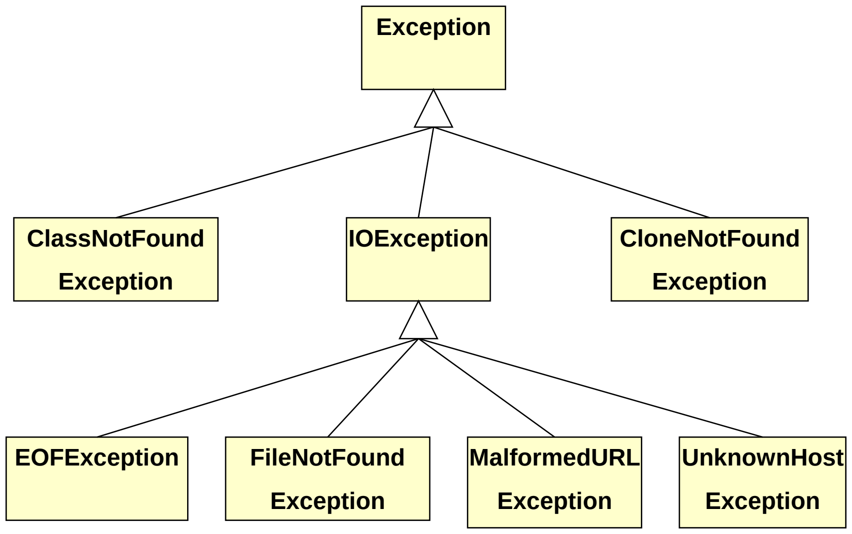
```
public class Driver
{
    public static void main (String [] args) throws IOException,
      NumberFormatException
    {
        TCExample eg = new TCExample ();
        eg.method();
    }
}
```

Creating Your Own Exceptions



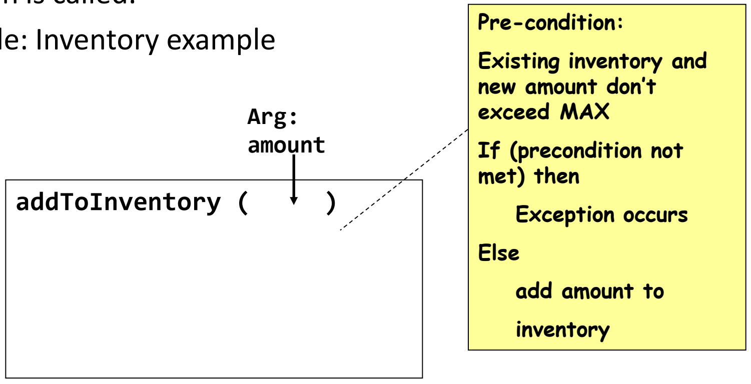
Excerpt from Big Java by C. Horstmann p. 562

Class Exception: The Local Inheritance Hierarchy



Writing New Exceptions

- Typical approach: tie the exception into preconditions
- Remember: preconditions are things that must be true when a function is called.
- Example: Inventory example

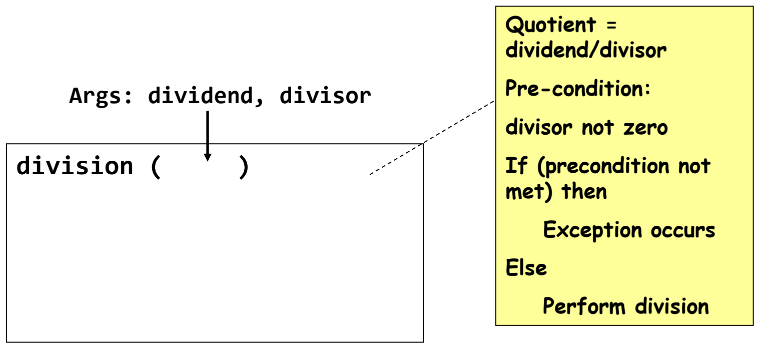


```
Pre-condition:
Existing inventory and new amount don't exceed MAX
If (precondition not met) then
    Exception occurs
Else
    add amount to
    inventory
```

James Tam

Writing New Exceptions (2)

- Example 2: Division



```
Quotient = dividend/divisor
Pre-condition:
divisor not zero
If (precondition not met) then
    Exception occurs
Else
    Perform division
```

James Tam

Writing New Exceptions: An Example

Location of the online example:

`/home/233/examples/exceptions/writingExceptions/inventoryExample`

Writing New Exceptions: `Driver` Class

```
public class Driver
{
    public static void main(String [] args)
    {
        Inventory chinook = new Inventory();
        try
        {
           chinook.add(10);
        }
        catch (InventoryOverMaxException e)
        {
           System.out.print(">>Too much to be added to
                             stock<<");
        }
```

Writing New Exceptions: `Driver` Class (2)

```
System.out.println(chinook.showStockLevel ());
try
{
   chinook.add(10);
}
catch (InventoryOverMaxException e)
{
   System.out.println(">>Too much to be added to
                       stock<<");
}
```

Writing New Exceptions: `Driver` Class (3)

```
System.out.println(chinook.showStockLevel ());
try
{
   chinook.add(100);
}
catch (InventoryOverMaxException e)
{
   System.out.println(">>Too much to be added to
                       stock<<");
}
```

Writing New Exceptions: Driver Class (4)

```
        System.out.println(chinook.showStockLevel ());
        try
        {
           chinook.remove(21);
        }
        catch (InventoryUnderMinException e)
        {
           System.out.println(">>Too much to remove from
           stock<<");
        }
        System.out.println(chinook.showStockLevel ());
    }
}
```

Writing New Exceptions: Class Inventory

```
public class Inventory
{
    public final int CRITICAL = 10;
    public final int MIN = 0;
    public final int MAX = 100;
    private int stockLevel = 0;

     public boolean inventoryTooLow()
     {
          if (stockLevel < CRITICAL)
              return true;
          else
              return false;
    }
```

Writing New Exceptions: Class Inventory (2)

```
public void add(int amount) throws InventoryOverMaxException
  {
     int temp;
     temp = stockLevel + amount;
     if (temp > MAX)
     {
        throw new InventoryOverMaxException("Adding " +
           amount + " item(s) " +
           "will cause stock to become greater than "
           + MAX + " units");
     }
    else
          stockLevel = stockLevel + amount;
   }
```

"Throws":

- **An exception of type <E> can occur in this method**

"Throw":

- **Instantiates an exception of type <E>**
- **Execution transfers back to the 'catch' block of the caller**

Writing New Exceptions: Class Inventory (3)

```
public void remove(int amount) throws
  InventoryUnderMinException {
    int temp;
    temp = stockLevel - amount;
    if (temp < MIN) {
        throw new InventoryUnderMinException("Removing " +
          amount + " item(s) will cause stock to become less "
          than " + MIN + " units");
     }
     else
         stockLevel = temp;
  }

  public String showStockLevel ()  {
       return("Inventory: " + stockLevel);
  }
}
```

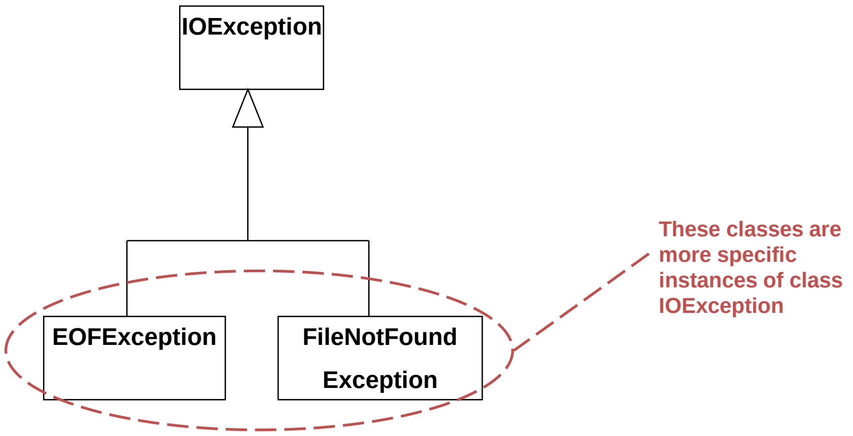
Writing New Exceptions: Class `InventoryOverMaxException`

```
public class InventoryOverMaxException extends Exception
{
    public InventoryOverMaxException()
    {
        super ();
    }

    public InventoryOverMaxException(String s)
    {
        super (s);
    }
}
```

Writing New Exceptions: Class `InventoryUnderMinException`

```
public class InventoryUnderMinException extends Exception
{
    public InventoryUnderMinException()
    {
        super();
    }

    public InventoryUnderMinException(String s)
    {
        super(s);
    }
}
```

Inheritance Hierarchy For `IOExceptions`


IOException
EOFException
FileNotFound Exception
These classes are more specific instances of class IOException

Inheritance And Catching Exceptions

- If you are catching a sequence of exceptions then make sure that you catch the exceptions for the child classes before you catch the exceptions for the parent classes
- Deal with the more specific case before handling the more general case

Inheritance And Catching Exceptions (2)

Correct

```
try
{

}
catch (EOFException e)
{

}
catch (IOException e)
{

}
```

Incorrect

```
try
{

}
catch (IOException e)
{

}
catch (EOFException e)
{

}
```

You Should Now Know

- The benefits of handling errors with an exception handler rather than employing a series of return values and conditional statements/branches.
- How to handle exceptions
  - Being able to call a method that may throw an exception by using a `try-catch` block
  - What to do if the caller cannot properly handle the exception
  - What is the finally clause, how does it work and when should it be used
- How to write your classes of exceptions
- The effect of the inheritance hierarchy when catching exceptions