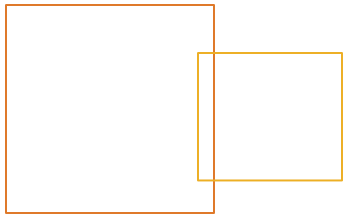
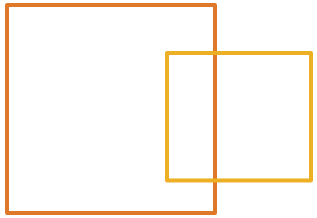
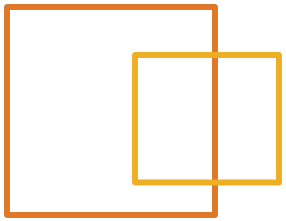


Fast Track to Java

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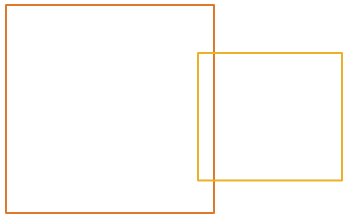
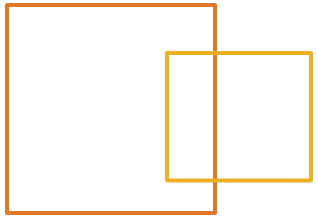
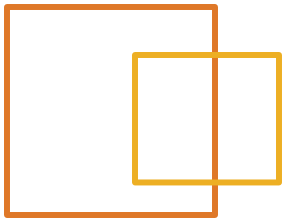
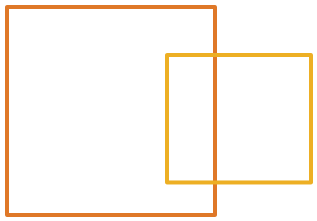
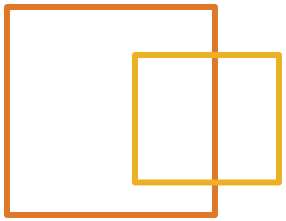





Exceptions

Objectives





- At the end of this module you should be able to
- Describe exceptions & understand their importance
- Describe the Java exception hierarchy
- Declare method signatures with throws
- Define an application exception hierarchy
- Use the try-throw-catch construct
- Use nested try blocks
- Use the finally clause
- Rethrowing exceptions

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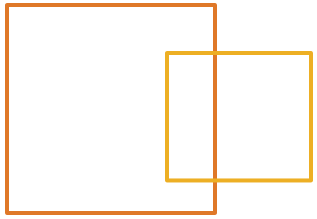
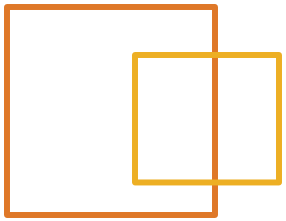
Exceptions





- Java incorporates an exception handling mechanism into the language structure
- Exceptions are objects that represent what went wrong
    - Could be an exceptional case
    - Could be the expected negative result of a behavior
    - Could be the unexpected negative result of a behavior
    - If handled properly, many are recoverable
- Exceptions are standard Java objects with a specific type hierarchy

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Exceptions (cont.)

- An Exception is not always synonymous with a bug
  - Programming faults (bugs)
  - System faults like a down network (not a bug)
- Can manage exceptions - which means either:
  - Code responds to an exception so a problem can be fixed and then continue processing
  - Shutting the application down gracefully in order to do as little damage as possible

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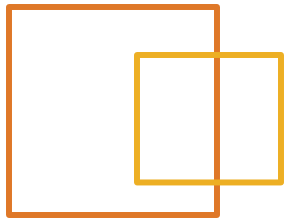
Reporting A Problem



- Try to perform the interaction
  result = getResult();
- The interaction is determined to be a failure
  if(result != expectedResult) {
- An exception object is thrown to describe the failure
  throw new DidntWorkException("It Broke");
- Exceptions are handled "further up"
- Note; always use ***throw new XyzException()***
  - Stack trace information is prepared including the line number where ***new*** is executed

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Exception Classification

- All exceptions are Java objects
- They are specific types of Java objects
  - Subclasses of ***java.lang.Throwable***
  - Typically you won't work directly with ***Throwable***
  - Will cause execution flow to be redirected
- Two subclasses of ***Throwable***:
  - Error—environmental issue probably won't recover from
  - ***OutOfMemoryError***, ***StackOverflowError***
  - Exception—programming/environmental issue, might try to recover
  - ***NullPointerException***, ***IOException***

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Exception Classification (cont.)

- There are two types of Exceptions
- Checked—direct subclasses of ***`Exception`***
  - Compiler requires this be handled in code
  - Typically *recoverable* application-level issues
  - E.g. ***`FileNotFoundException`***
- Unchecked—***`RuntimeException`***
  - Not checked by compiler (hence “unchecked”)
  - Typically programming bugs “that shouldn’t happen”
  - ***`NullPointerException`***
  - ***`ArraryIndexOutOfBoundsException`***
  - Don’t try to fix at runtime, fix the bug!

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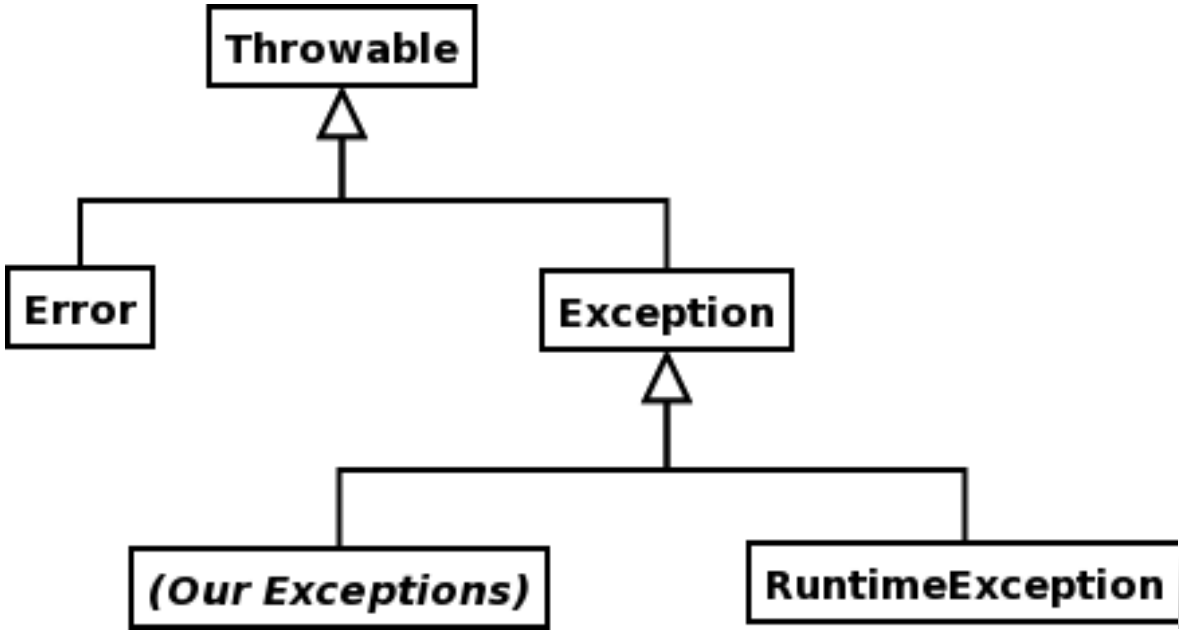
Classification of Exceptions in Java



Java Exception Hierarchy

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Exception Handling, Option 1

- try
  - Contains code that might fail
  - Flow control jumps from try to catch if an exception occurs
- catch
  - Contains the handling/recovery code
  - Executed only if a detected exception occurs
- finally
  - Always executed--use for final clean up
  - Can Have one finally block per try

```
try {
  //delicate code
} catch (ExceptionType e) {
  //recovery
} finally {
  //final clean up
}
```

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Exception Handling 1 (cont.)

- It is permitted to have multiple catch blocks
- When designing multiple exception handlers consider
  - Exceptions that might arise
  - Class hierarchy of those exceptions
- These govern the order of the catch blocks

Specific

Generic

```
try {
  //some network code
} catch (IOException ioe) {
  //do some IO recovery
} catch (Exception e) {
  //do some generic recovery
} finally {
  //do clean up
}
```

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Try-Throw-Catch Example

```
public class ExceptionsExample {
    public static void main(String[] args) {
      ExceptionsExample testObj = new ExceptionsExample();
      testObj.exec(args[0]);
    }
    public void exec(String option) {
      try {
    if (option.equals("fail")) {
      throw new Exception();
         }
         if (option.equals("access")) {
           throw new IllegalAccessException();
         }
         System.out.println("No Exception Thrown");
      } catch (IllegalAccessException e) {
         System.err.println("IOExcepton caught");
      } catch (Exception e) {
         System.err.println("Exception caught");
      }
    }
}
```

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Exception Handling, Option 2

- Sometimes, this method cannot handle the problem
- So, do nothing, the method is quit, and the exception is passed to the caller
- For *checked exceptions*, the method must declare this possibility

```
public void mightBreak() throws BrokenException {
     // do stuff
     if (itBroke) {
       throw new BrokenException("it Broke");
     }
     // rest of method
```

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Implementing an Exception Hierarchy

```
class BankException extends Exception {}
class ATMException extends BankException {}

public class BankExceptions {
  public static void main(String[] args) {
    // here is the try block
    try {
      throw new ATMException();
    } catch (ATMException e) {
      System.err.println("Caught ATMException");
    } catch (BankException e) {
      System.err.println("Caught BankException");
    }
  }
}
// Output is: Caught ATMException
```

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Implementing an Exception Hierarchy

```
class BankException extends Exception {}
class ATMException extends BankException {}

public class BankExceptions2 {
  public static void main(String [] args) {
    try {
      throw new ATMException ();
    } catch(BankException e) {
      System.err.println("Caught BankException");
    }
  }
}
// Output is: Caught BankException
```

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Implementing an Exception Hierarchy

```
class BankException extends Exception {}
class ATMException extends BankException {}

public class BankExceptions3 {
  public static void main(String[] args) {
    try {
      throw new ATMException();
    } catch (BankException e) {
      System.err.println("Caught BankException");
    } catch (ATMException e) {
      System.err.println("Caught ATMException");
    }
  }
}
// This code will not compile.
// catch(ATMException e) would never be reached
```

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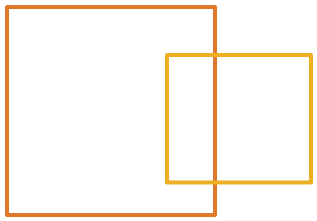
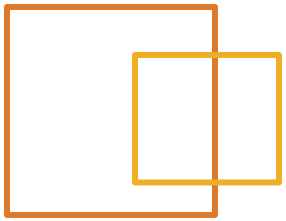
Exception API





- Functionality of ***`Exception`*** is all inherited from Throwable
- Interesting ***`java.lang.Throwable`*** APIs

`getMessage`

`getStackTrace`

`initCause`

`printStackTrace`

`toString`

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Reporting an Exception Stack Trace

```
class BankException extends Exception {
  BankException(String msg) { super(msg); }
}
public class BankExceptions4 {
  public static void main(String [] args) {
    try {
      throw new BankException ("I'm a BankException");
    } catch(BankException e) {
      System.err.println(e.getMessage());
      e.printStackTrace();
    }
  }
}
// Output is
// I'm a BankException
// BankException: I'm a BankException
// at BankExceptions4.main(BankExceptions4.java:7)
```

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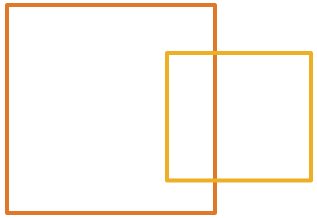
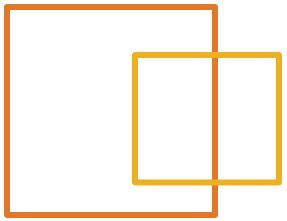
Nesting





- Java's exception mechanism supports nesting

- You can have
  - Try-catch blocks in try blocks
  - Try-catch blocks in catch blocks
  - Try-catch blocks in finally blocks

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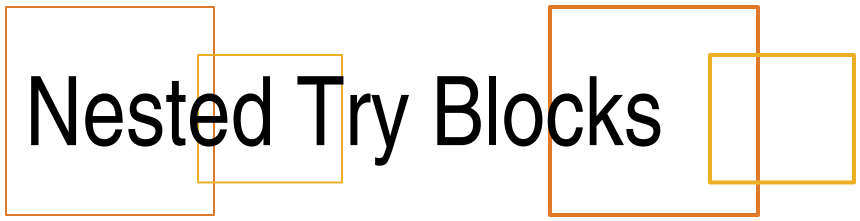
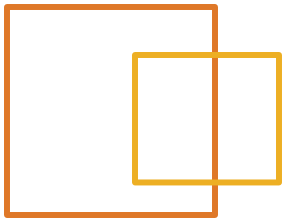
Nested Try Blocks





```
class e1  extends Exception{}
class e2 extends Exception{}

public class Ex9_6 {
  public static void main(String[] args) {
    Ex9_6 testObj = new Ex9_6();
    testObj.exec(args[0]);
  }
  public void exec(String option) {
    // here is the outer try block
    try {
      if (option.equals("outer"))
        throw new e1();

    . . .
```

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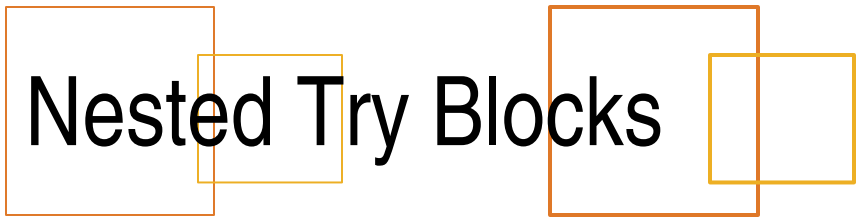
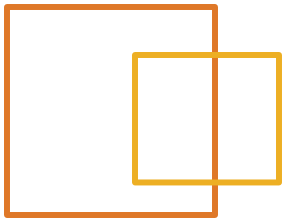
Nested Try Blocks





```
    // inner try block
    try {
      if (option.equals("1"))
        throw new e1();
      if (option.equals("2"))
        throw new e2();
      System.out.println("No Inner Exception Thrown");
    } catch (e2 e) {
      System.err.println("inner e2 caught");
    }
    System.out.println("No Outer Exception Thrown");
  } catch (e1 e) {
    System.err.println("outer e1 caught");
  } catch (Exception e) {
    System.err.println("outer e2 caught");
  }
}
```

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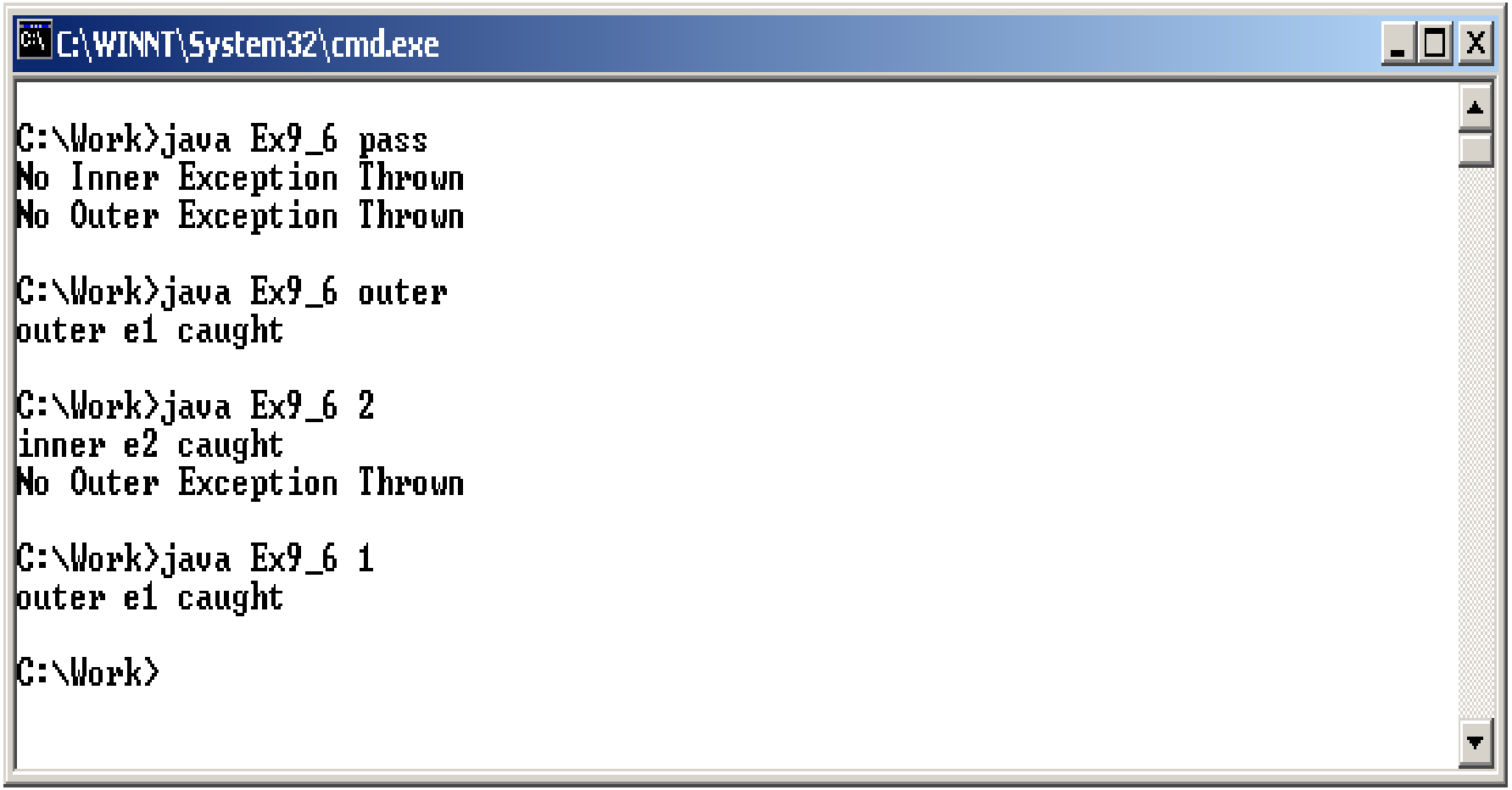
Nested Try Blocks



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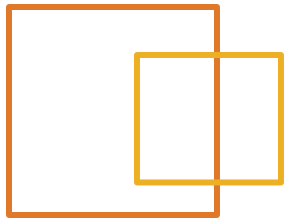
The finally Block Again



- All finally blocks are always executed
  - Whether the exception is thrown or not
  - Whether the exception is handled or not
  - Whether the exception came from a nested block or not
- Exceptions:
  - finally might not *complete* if another exception arises in the middle of processing the block
  - A call to `System.exit()` will also abandon current processing
  - Turning the power off or killing the VM process can also prevent finally from completing

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Rethrowing Exceptions

- Sometimes, a low level exception cannot be handled, but it's not descriptive to the caller
    - Consider catching the exception, then throwing a new, application level, exception that is more descriptive

```
try {
  doCreditCardNetworkOperations();
} catch (SocketTimeoutException ne) {
  // network not available, try again later…
  throw new RetryCreditCardLaterException(ne);
}
```

- Notice exception constructor allows nesting of "original" exception (aka the "Cause") inside the new "semantic" exception

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Custom Exceptions

- In many cases you will want to create application specific exceptions
- Extend the ***`Exception`*** class
  - Subclass an existing exception type
  - Choose something that is a reasonable generalization of the problem if possible: e.g. IOException for I/O errors.
  - Otherwise choose between ***`RuntimeException`***, ***`Error`***, and ***`Exception`***
- Maintain the reason message and cause
  - Invoke superclass constructors to manage this

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Rules For Overloading Methods

- Overloading methods must be entirely compatible with the method the replace
    - Liskov substitution principle
- So, overloading method must not break compiler checks regarding exceptions either
    - May not throw checked exceptions from an overloading method that were not declared for the base method
- This also applies to interface implementation methods
    - Generalized methods often declare exceptions they do not actually throw

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Assertions In Java

```
assert <boolean> [ : <message> ]
```

- Expresses design assumptions—provides excellent form of documentation
- Must not be part of the correctness of the program
- Normally removed from binary prior to execution
- Enable tests using: `java -ea <myclass>`

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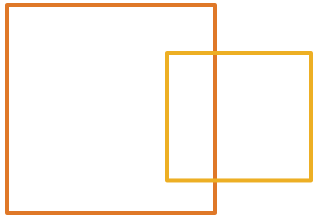
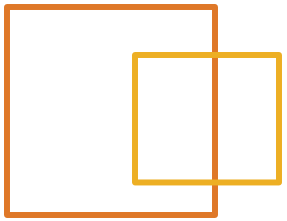
Summary





We covered

- Describing exceptions are & why they are unavoidable as a rule
- Declaring method signatures with throws
- Describing the Java exception hierarchy
- Defining an application exception hierarchy
- Using the try-throw-catch construct
- Using nested try blocks
- Using the finally clause
- Rethrowing exceptions

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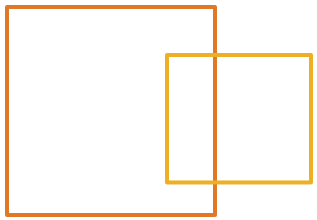
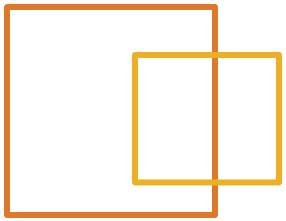
Lab 6





- Exceptions
  - You are going to add code to your Person class constructor to check that the birthDay and birthMonth passed in are valid. If not, you should throw a InvalidDate exception.
  - Which means that you are first going to have to create a new Exception class called InvalidDateException.