To Think About

• A student adds a JUnit test:

```java
@Test
public void mogrifyTest() {
    assertEquals("mogrify fails", new int[]{2, 4, 8, 12}, MyClass.mogrify(new int[]{1, 2, 4, 6}));
}
```

The test always seems to fail, no matter what `mogrify` does. Why?

• A student sees this in an autograder log:

```
Fatal: no proj0/galaxy directory.
```

What is likely to be the problem?

• A student does not see his proj0 submission under the Scores tab.

What can be the problem?
What to do About Errors?

• Large amount of any production program devoted to detecting and responding to errors.

• Some errors are external (bad input, network failures); others are internal errors in programs.

• When method has stated precondition, it’s the client’s job to comply.

• Still, it’s nice to detect and report client’s errors.

• In Java, we *throw exception objects*, typically:
  
  ```java
  throw new SomeException (optional description);
  ```

• Exceptions are objects. By convention, they are given two constructors: one with no arguments, and one with a descriptive string argument (which the exception stores).

• Java system throws some exceptions implicitly, as when you dereference a null pointer, or exceed an array bound.
Catching Exceptions

- A throw causes each active method call to terminate abruptly, until (and unless) we come to a try block.

- Catch exceptions and do something corrective with try:

  ```java
  try {
      Stuff that might throw exception;
  } catch (SomeException e) {
      Do something reasonable;
  } catch (SomeOtherException e) {
      Do something else reasonable;
  }
  Go on with life;
  ```

- When SomeException exception occurs during “Stuff…” and is not handled there, we immediately “do something reasonable” and then “go on with life.”

- Descriptive string (if any) available as e.getMessage() for error messages and the like.
Catching Exceptions, II

• Using a supertype as the parameter type in a catch clause will catch any subtype of that exception as well:

```java
try {
    Code that might throw a FileNotFoundException or a MalformedURLException ;
    catch (IOException ex) {
        Handle any kind of IOException ;
    }
}
```

• Since `FileNotFoundException` and `MalformedURLException` both inherit from `IOException`, the catch handles both cases.

• Subtyping means that multiple catch clauses can apply; Java takes the first.

• Stylistically, it’s nice to be more (concrete) about exception types where possible.

• In particular, our style checker will therefore balk at the use of `Exception`, `RunTimeException`, `Error`, and `Throwable` as exception supertypes.
Catching Exceptions, III

- There's a relatively new shorthand for handling multiple exceptions the same way:

```java
try {
    Code that might throw IllegalArgumentException
    or IllegalStateException;
    catch (IllegalArgumentException|IllegalStateException ex) {
        Handle exception;
    }
}
```
Exceptions: Checked vs. Unchecked

- The object thrown by `throw` command must be a subtype of `Throwable` (in `java.lang`).

- Java pre-declares several such subtypes, among them
  - `Error`, used for serious, unrecoverable errors;
  - `Exception`, intended for all other exceptions;
  - `RuntimeException`, a subtype of `Exception` intended mostly for programming errors too common to be worth declaring.

- Pre-declared exceptions are all subtypes of one of these.

- Any subtype of `Error` or `RuntimeException` is said to be `unchecked`.

- All other exception types are `checked`. 
Unchecked Exceptions

• Intended for
  - Programmer errors: many library functions throw IllegalArgumentException when one fails to meet a precondition.
  - Errors detected by the basic Java system: e.g.,
    * Executing \texttt{x.y} when \texttt{x} is null,
    * Executing \texttt{A[i]} when \texttt{i} is out of bounds,
    * Executing (\texttt{String}) \texttt{x} when \texttt{x} turns out not to point to a \texttt{String}.
  - Certain catastrophic failures, such as running out of memory.

• May be thrown anywhere at any time with no special preparation.
Checked Exceptions

• Intended to indicate exceptional circumstances that are not necessarily programmer errors. Examples:
  - Attempting to open a file that does not exist.
  - Input or output errors on a file.
  - Receiving an interrupt.

• Every checked exception that can occur inside a method must either be handled by a try statement, or reported in the method’s declaration.

• For example,

        void myRead() throws IOException, InterruptedException { ... }

means that myRead (or something it calls) might throw IOException or InterruptedException.

• Language Design: Why did Java make the following illegal?

        class Parent { ... }
        class Child extends Parent {
            void f() { ... }
            void f() throws IOException { ... }
        }

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Good Practice

- Throw exceptions rather than using print statements and System.exit everywhere,
- ... because response to a problem may depend on the caller, not just method where problem arises.
- Nice to throw an exception when programmer violates preconditions.
- Particularly good idea to throw an exception rather than let bad input corrupt a data structure.
- Good idea to document when methods throw exceptions.
- To convey information about the cause of exceptional condition, put it into the exception rather than into some global variable:

```java
class MyBad extends Exception {
    public IntList errs;
    MyBad(IntList nums) { errs=nums; }
}

try {
    ...
} catch (MyBad e) {
    ... e.errs ...
}
```