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# Software Testing

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# Learning Objectives

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- Understand the importance of testing and discover types of testing for programs
  - Apply testing principles and perform basic unit testing practices with the JUnit framework for Java code.
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# Testing

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- Testing is the process of finding software faults
  - **Fault:** “an incorrect step, process, or data definition in a program”

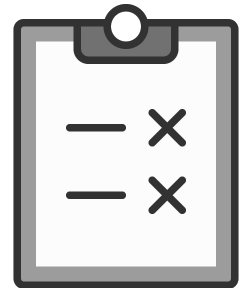
Example: Program to determine if a given number is odd or even.

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# Why Test Software?

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- Test cases uncover failure by finding where a program's *actual behavior* deviates from the *expected behavior*.
- Testing increases confidence that your program works correctly and meets the requirements.
  - No such thing as perfect code!
- Test Early and Test Often!



# Benefits

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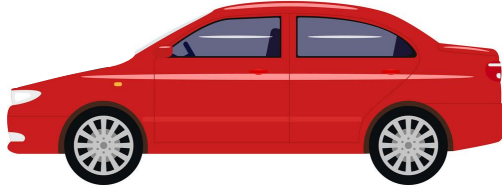


- Improves code quality,
  - Catching bugs earlier reduces debugging time and costs,
  - Provides documentation,
  - Enhances software maintenance,
  - Increases ability to add more features iteratively (agile),
  - and more!
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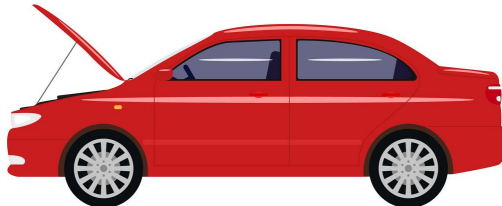
# Types of Testing

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1. **Black Box Testing:** ignores the internals of the program and focuses on functionality



2. **White Box Testing:** uses code to guide testing



# White Box Testing

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- Also known as unit testing
  - **unit**: individual functions or methods
- Test all of your program's methods (except main!)
- Create testing a separate Java test class
  - Usually <ClassName>Test.java in a test/ folder

src/EvenOrOdd.java → test/EvenOrOddTest.java

# Cyclomatic Complexity

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- Measure of a method's complexity: number of independent paths in the basis set of method.
- ***Minimum*** number of test cases to write for a method
  - **Code Coverage:** percentage of lines executed in tests

**Cyclomatic Complexity** = #decisions + 1

- *decisions: if, else if, loop control, boolean operators,...*

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```
public static String evenOdd(int num) {  
    if (num == 0) {  
        return "Even";  
    } else if (num == 2) {  
        return "Even";  
    } else if (num == 4) {  
        return "Even";  
    } else if (num == 6) {  
        return "Even";  
    } else if (num == 8) {  
        return "Even";  
    } else {  
        return "Odd";  
    }  
}
```

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```
public static String even(int num) {  
    if (num == 0 || num == 2 || num == 4 || num == 6 || num == 8) {  
        return "Even";  
    }  
    return "Odd";  
}
```

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```
public static void evenOddToNum(int num) {  
    for (int i = 1; i <= num; i++) {  
        if (i % 2 != 0) {  
            System.out.print(i + " ");  
        }  
    }  
}
```

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# JUnit

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- Unit testing framework for Java
  - External library
  - JUnit must be downloaded and referenced when compiling and executing
    1. hamcrest-core-1.3.jar
    2. junit-4.12.jar
    - [go.ncsu.edu/davidson-chris-demo](http://go.ncsu.edu/davidson-chris-demo)
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# JUnit Conventions

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- Test cases can be broken out into individual methods.
- Naming convention:

test<MethodName><DescriptionOfTest>

```
/**
 * Determines if a number is even or odd
 * @param num number input by user
 * @return String if value is even or odd
 */
public static String evenOdd(int num) {
```

0?	testEvenOddZero
1?	testEvenOddOddNumber
2?	testEvenOddEvenNumber
50?	testEvenOddFifty
negative number?	testEvenOddNegative
9.5?	testEvenOddDecimal

- @Test is used to identify each test method in your test class.
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# Assert Statements

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- Assert statements “check” your expected and actual results
  - If the expected results do not match the actual results, the test will FAIL
  - A test case must have ***at least 1*** assert statement, otherwise the test case isn't actually testing anything!
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# Assert Statements

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Statement	Description
<code>assertTrue(message, value)</code>	asserts that the value passed as a parameter is boolean true. If it is not true, the test case will fail with the given message.
<code>assertFalse(message, value)</code>	asserts that the value passed as a parameter is boolean false. If it is not false, the test case will fail with the given message.
<code>assertEquals(message, expectedValue, actualValue)</code>	asserts that expectedValue equals the actualValue. If the two values are not equal, the test case will fail with the given message.

# Assert Statements

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```
public static String evenOdd(int num) {  
    if (num == 0 || num == 2 || num == 4 || num == 6 || num == 8) {  
        return "Even";  
    } else {  
        return "Odd";  
    }  
}
```

1. assertEquals("The expected output is Even", "Even", evenOdd(6)); // PASS
2. assertEquals("The expected output is Odd", "Odd", evenOdd(1)); // PASS
3. assertEquals("The expected output is Even", "Even", evenOdd(10)); // FAIL
4. assertTrue("The expected output is Odd", "Odd".equals(evenOdd(99))); // PASS
5. assertFalse("The expected output is Even", evenOdd(8).equals("Even")); // FAIL



# Project Structure

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**project/** (top-level project directory)

- **src** (where your .java files should be stored)
  - **test** (where your test .java files should be stored)
  - **lib** (where your Junit (and other external libraries) archive files should be stored)
  - **bin** (where your compiled .class files should be stored)
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# Compilation

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## 1. Compiling Source Code:

```
$ javac -d bin src/<ClassName>.java
```

## 2. Compiling Test Code:

```
$ javac -d bin -cp bin:lib/* test/<ClassName>Test.java
```

```
$ javac -d bin -cp "bin;lib\*" test/<ClassName>Test.java
```

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# Execution

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## 1. Executing Source Code:

```
$ java -cp bin <ClassName>
```

## 2. Test Code:

```
$ java -cp bin:lib/* org.junit.runner.JUnitCore <ClassName>Test
```

```
$ java -cp "bin;lib\*" org.junit.runner.JUnitCore <ClassName>Test
```

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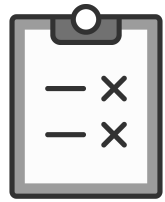
# Remainder of Class

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- Live Coding Example: Testing EvenOrOdd.java
  - Group or HW Assignment
    - Fix EvenOrOdd and write EvenOrOddTest.java
  - Prerequisites:
    - IDE or text editor
    - Java 11.0.7
    - hamcrest-core-1.3.jar and junit-4.12.jar
    - Project Structure (src, bin, test, and lib)
    - [go.ncsu.edu/davidson-chris-demo](https://go.ncsu.edu/davidson-chris-demo)
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# Wrap Up

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- Testing is crucial for developing reliable systems and provides many benefits to development teams
  - White box (know the code) and black box (ignore code) are two types of testing
  - Cyclomatic complexity measures the decisions in your code
  - JUnit: automated unit testing framework for Java
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