# Unit Testing in Java

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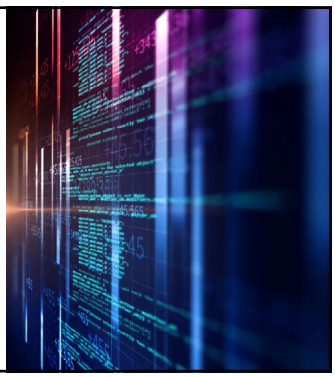

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## Unit Testing



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## Unit Testing

- Bottom line, you *have to* test your code to get it working
- You *can do* ad hoc testing by testing whatever occurs to you at the moment
  - For example:
    - Calling random methods with different inputs from your *main* method and printing/comparing the results
    - Or running your program and trying different inputs for a *Scanner*
- Or you *can write* a set of unit tests that can be run at any time
  - This will always test your code in the same ways
  - It's just like the testing class we write to test our main program in Python



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## Unit Testing

- The *disadvantages* of writing unit tests:
  - It *can* require (a lot of) extra programming
    - But use of a good testing framework can help with the process
  - You don't have time to do all that extra work
    - But testing reduces debugging time more than the amount of time spent building the actual tests
- The *advantages* of writing unit tests:
  - Guaranteed, your program will have fewer bugs
  - It will be a lot easier to maintain and modify your program
    - This is a huge win for programs that get actual use in production!



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## JUnit

- JUnit is a (Java) framework for writing unit tests
  - JUnit uses Java's *reflection* capabilities, which allows Java programs to examine their own code
  - JUnit helps the programmer:
    - Define and execute tests
    - Formalize requirements and clarify program architecture
    - Write and debug code
    - Integrate code and always be ready to release a working version



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## Terminology

- A unit test tests the units (methods) in a *single* class
- A test case tests the response of a *single* unit (method) to a particular set of inputs
  - You can (and should) have multiple test cases for a single unit test method
- An integration test is a test of how well classes and methods work together
  - Integration testing (testing that it all works together) is not well supported by Junit and we won't cover this



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## Assert Methods

- The unit testing process:
  - Call the method being tested in your program and get the actual result
  - "Assert" what the correct result should be with one of the assert methods
  - Repeat steps as many times as necessary
- An assert method is a JUnit method that performs a test, and throws an AssertionError if the test fails
  - JUnit catches these Errors and shows you the result



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## Assert Methods

- Some assert methods:

```
void assertTrue(boolean test)
void assertTrue(boolean test, String message)
```

  - Throws an *AssertionError* if the test fails
  - The optional *message* is included in the Error

```
void assertFalse(boolean test)
void assertFalse(boolean test, String message)
```

  - Throws an *AssertionError* if the test fails
  - The optional *message* is included in the Error



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## Example - Counter Class

- As an example, let's look at a trivial "Counter" class
  - The class will declare a counter (int) and initialize it to zero
  - The *increment* method will add one to the counter and return the new value
  - The *decrement* method will subtract one from the counter and return the new value
- A good approach is to write the program method stubs first, and let Eclipse generate the test method stubs
- Don't be alarmed if, in this simple example, the JUnit tests are more code than the class itself



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## Example - Counter Class

```
public class Counter {

    int count = 0;

    public int increment() {
        this.count += 1;
        return this.count;
    }

    public int decrement() {
        this.count -= 1;
        return this.count;
    }

    public int getCount() {
        return this.count;
    }
}
```

- Is JUnit testing overkill for this little class?
  - Doesn't matter, writing JUnit tests for trivial classes is no big deal
- Note: Often, you won't write tests for simple "getter" methods like *getCount*



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## Example – JUnit Tests for Counter Class

```
public class CounterTest {

    Counter counter1; //declare a Counter for testing

    @BeforeEach
    void setUp() throws Exception {
        //initialize the Counter here
        this.counter1 = new Counter();
    }

    @Test
    void testIncrement() {
        assertTrue(this.counter1.increment() == 1);
        assertTrue(this.counter1.increment() == 2);
        assertEquals(3, this.counter1.increment());
    }

    @Test
    void testDecrement() {
        assertEquals(-1, this.counter1.decrement());
        assertTrue(this.counter1.decrement() == -2);
    }

}
```

- The *setUp* method (annotated by @BeforeEach) runs before each unit test method
  - This is just like the *setUp(self)* testing function in Python
- Each unit test (annotated by @Test) begins with a *brand new* counter
- Note: You can't be concerned with the order in which unit test methods run



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## Counter Project



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## Create Counter Class

Counter.java

```
/**
 * Represents a count, with methods.
 * @author lbrandon
 *
 */
public class Counter {

    //instance variable(s)

    /**
     * Stores internal count.
     * Primitive int, defaults to 0.
     */
    int count;

```



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## Create Counter Class

```
    //methods

    /**
     * Increments count.
     * @return new value of count
     */
    public int increment() {
        this.count++;

        return this.count;
    }

    /**
     * Decrement count.
     * @return new value of count
     */
    public int decrement() {
        this.count--;

        return this.count;
    }

    /**
     * Returns current value of count.
     * @return count
     */
    public int getCount() {
        return this.count;
    }

```



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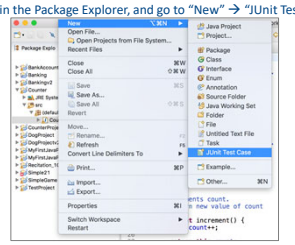
## Create JUnit Tests

- Select the class file in the Package Explorer, and go to "New" → "JUnit Test Case"



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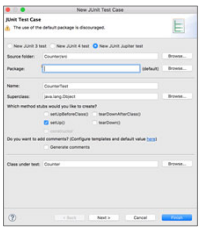
## Create JUnit Tests

- Use the default name provided for your JUnit Test Case class



- Make sure setUp() is checked



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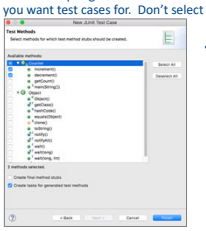
## Create JUnit Tests

- To have Eclipse generate test method stubs for you, use the checkboxes to decide which methods you want test cases for. Don't select Object or anything under it.



- Check Create tasks for generated test methods



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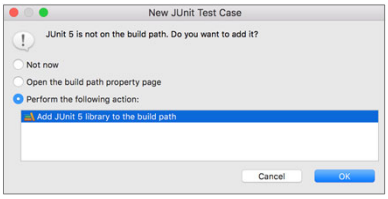
## Create JUnit Tests

- Add the JUnit 5 library to the project build path
  - This includes the necessary JUnit framework in your project



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## Create JUnit Tests

- Eclipse will add a new JUnit Test class in the same package (or default)
  - You'll see test method stubs to be implemented
  - The code in each test method is calling *fail* (with a message), to force the test methods to initially fail

Counter.java | CounterTest.java

```java
import static org.junit.jupiter.api.Assertions.*;

class CounterTest {

    @BeforeEach
    void setUp() throws Exception {
    }

    @Test
    void testIncrement() {
        fail("Not yet implemented"); // TODO
    }

    @Test
    void testDecrement() {
        fail("Not yet implemented"); // TODO
    }

}
```



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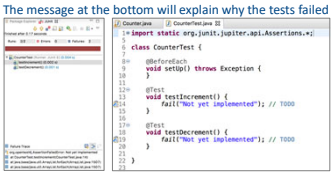
## Create JUnit Tests

- If you run the tests, they should ALL fail
  - Eclipse will open the JUnit panel (on the left)
    - The top bar will show red
    - The number next to "Failures" will show 2
    - The message at the bottom will explain why the tests failed





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## Create JUnit Tests

- Declare and initialize a Counter object for testing

Counter.java | CounterTest.java

```java
import static org.junit.jupiter.api.Assertions.*;

import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;

class CounterTest {

    Counter counter; //Declare a Counter for testing

    //runs before each unit test method
    //not required
    @BeforeEach
    void setUp() throws Exception {
        this.counter = new Counter(); //Initialize the Counter here
    }
```



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## Create JUnit Tests

- Implement the test methods, adding test cases with assert methods

```java
    @Test
    void testIncrement() {

        //asserts that calling increment returns 1
        assertTrue(this.counter.increment() == 1);

        //asserts that calling increment returns 2
        assertTrue(this.counter.increment() == 2);

        //increments again
        this.counter.increment();

        //asserts that calling increment again does not return 2
        assertFalse(this.counter.getCount() == 2, "should not return 2 after incrementing again");

        //asserts that 3 is equal to the new count
        assertEquals(3, this.counter.getCount());

        //asserts that 3 is not equal to calling increment again
        assertNotEquals(3, this.counter.increment());

    }
```



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## Create JUnit Tests

- Implement the test methods, adding test cases with assert methods

```java
    @Test
    void testDecrement() {
        //asserts that -1 is equal to calling decrement
        assertEquals(-1, this.counter.decrement());

        //asserts that calling decrement again returns -2
        assertTrue(this.counter.decrement() == -2);

        //decrements again
        this.counter.decrement();

        //asserts that calling decrement again does not return -2
        assertFalse(this.counter.getCount() == -2, "should not return -2 after decrementing again");

        //asserts that -3 is equal to the new count
        assertTrue(this.counter.getCount() == -3);

    }
```



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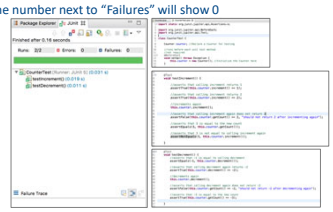
## Create JUnit Tests

- If you run the tests, they should ALL pass
  - In the JUnit panel (on the left) – the top bar will show green
  - The number next to "Failures" will show 0





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## More Assert Methods

```
void assertEquals(expected, actual)
void assertEquals(expected, actual, String message)
```

- *expected* and *actual* must both be Objects *or* the same primitive type
- For primitives, this method compares using ==
- For Objects, this method compares using the *equals* method
  - For your own objects, you'll need to define the *equals* method properly (as described in *"About_Equality"* lecture)

```
void assertArrayEquals(int[] expected, int[] actual)
void assertArrayEquals(int[] expected, int[] actual, String message)
```

- Asserts that two int arrays are equal



## Assert Methods with Floating Points Types

- Note: When you want to compare floating point types (e.g. double or float) with a high amount of precision
  - You should use *assertEquals* with the additional parameter *delta* to avoid problems with round-off errors while doing floating point comparisons
- The assert method syntax to use is:

```
void assertEquals(double expected, double actual, double delta)
```

  - This asserts that the *expected* and *actual* are equal, within the given *delta*
  - *delta* is typically a very small double (e.g. 0.000001) used for comparison
- For example:

```
void assertEquals(aDoubleValue, anotherDoubleValue, 0.000001)
```

  - This evaluates to: Math.abs(aDoubleValue – anotherDoubleValue) <= delta



## More Assert Methods

```
void assertNull(Object object)
void assertNull(Object object, String message)
```

- Asserts that the object is null (undefined)

```
void assertNotNull(Object object)
void assertNotNull(Object object, String message)
```

- Asserts that the object is not null

```
fail()
fail(String message)
```

- Causes the test to fail and throw an *AssertionFailedError*

## More Assert Methods

```
void assertThrows(Exception.class, () -> {
    //code that throws an exception
});
```

- Asserts that the enclosed code throws an Exception of a particular type

```
void assertDoesNotThrow(() -> {
    //code that does not throw an exception
});
```

- Asserts that the enclosed code does not throw an Exception

- For example:

```
String test = null;
assertThrows(NullPointerException.class, () -> {
    test.length();
});
```

  - Asserts that *test.length()* throws a NullPointerException
  - Why? *test* is null, so there is no method *length()*



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## Banking Project w/ Unit Testing



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## Banking Project w/ Unit Testing

- We'll unit test our previous "Banking" project, which had 3 classes
  - Bank
    - Includes the public static void main(String[] args) method
    - No updates needed
  - Customer
    - No updates needed
  - BankAccount
    - Updates needed!
- Create new unit testing classes
  - CustomerTest
    - For testing the Customer class
  - BankAccountTest
    - For testing the BankAccount class



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## Updated BankAccount Class

- Add a fastCashAmount instance variable

```java
package banking;

/**
 * Represents a checking/savings bank account for a customer.
 * @author lbrandon
 *
 */
public class BankAccount {

    //instance variables

    /**
     * Type of account (checking/savings).
     */
    String accountType;

    /**
     * Account balance.
     */
    double balance;

    /**
     * Customer for account.
     */
    Customer customer;

    /**
     * Fast cash for quick withdrawal.
     */
    double fastCashAmount;
```



## Updated BankAccount Class

- Update the constructor to set the initial value for fastCashAmount

```java
    //constructor

    /**
     * Creates a bank account of given type for given customer.
     * Sets default fast cash amount.
     * @param accountType for bank account
     * @param customer for this account
     */
    public BankAccount(String accountType, Customer customer) {
        this.accountType = accountType;
        this.customer = customer;

        //set default value for fast cash
        this.fastCashAmount = 60;
    }
```



## Updated BankAccount Class

- Add the fastWithDraw and setFastCashAmount methods

```java
    /**
     * Withdraws the fast cash amount.
     * @throws Exception if amount is greater than available balance
     */
    public void fastWithDraw() throws Exception {
        this.withdraw(this.fastCashAmount);
    }

    /**
    * Sets the fast cash amount, if the amount is greater than 0.
    * @param amount to set as fast cash
    */
    public void setFastCashAmount(double amount){
        if(amount > 0){
            this.fastCashAmount = amount;
        }
    }
```

## Updated BankAccount Class

- Update the deposit method

```java
    /**
     * Deposits the given balance, if the balance is greater than 0.
     * @param balance to add
     */
    public void deposit(double balance) {
        if (balance > 0) {
            this.balance += balance;
        }
    }
```



## Create CustomerTest Class

Bank.java | BankAccount.java | Customer.java | CustomerTest.java

```java
package banking;

import static org.junit.jupiter.api.Assertions.*;

class CustomerTest {

    //Declare Customer for testing
    Customer customer;

    @BeforeEach
    void setUp() throws Exception {
        //Initialize Customer here
        this.customer = new Customer("Brandon");
    }

    @Test
    void testSetAddress() {

        //Get expected address, should be null to start
        assertNull(this.customer.getAddress());

        //Set new address
        this.customer.setAddress("Brooklyn, NY");

        //Get expected address
        assertEquals("Brooklyn, NY", this.customer.getAddress());

        //Set new address
        this.customer.setAddress("Cranston, RI");

        //Get expected address
        assertEquals("Cranston, RI", this.customer.getAddress());
    }
}
```



## Create BankAccountTest Class

Bank.java | BankAccount.java | BankAccountTest.java

```java
package banking;
import static org.junit.jupiter.api.Assertions.*;

class BankAccountTest {

    //Declare Customer and BankAccounts for testing
    Customer customer;
    BankAccount myCheckingAccount;
    BankAccount mySavingsAccount;

    //runs before each test method
    @BeforeEach
    void setUp() throws Exception {

        //Initialize Customer and BankAccounts here
        this.customer = new Customer("Brandon");
        this.myCheckingAccount = new BankAccount("checking", this.customer);
        this.mySavingsAccount = new BankAccount("savings", this.customer);
    }
```

## Create BankAccountTest Class

```java
    @Test
    void testDeposit() {

        //make deposit
        this.myCheckingAccount.deposit(100);

        //test current balance
        assertEquals(100, this.myCheckingAccount.getBalance());

        //make deposit of negative amount
        //should ignore this
        this.myCheckingAccount.deposit(-100);

        //balance should be the same
        assertEquals(100, this.myCheckingAccount.getBalance());

        //make deposit of 0
        //should ignore this
        this.myCheckingAccount.deposit(0);

        //balance should be the same
        assertEquals(100, this.myCheckingAccount.getBalance());
    }
```



## Create BankAccountTest Class

```java
    @Test
    void testWithdraw() {

        //make deposit as setup
        this.mySavingsAccount.deposit(100);

        //test balance
        assertEquals(100, this.mySavingsAccount.getBalance());

        //try to make withdrawal
        try {
            this.mySavingsAccount.withdraw(80);
        } catch (Exception e) {
            // TODO Auto-generated catch block
            e.printStackTrace();
        }

        //test balance
        assertEquals(20, this.mySavingsAccount.getBalance());
```



## Create BankAccountTest Class

```java
        //try to make withdrawal greater than balance
        //expects Exception (error)
        assertThrows(Exception.class, () -> {
            this.mySavingsAccount.withdraw(21);
        });

        //balance remains the same
        assertEquals(20, this.mySavingsAccount.getBalance());

        //try to make withdrawal
        //doesn't expect Exception (error)
        assertDoesNotThrow(() -> {
            this.mySavingsAccount.withdraw(19);
        });

        //test balance
        assertEquals(1, this.mySavingsAccount.getBalance());
    }
```

## Create BankAccountTest Class

```java
    @Test
    public void testWithFastWithdraw() {

        //make deposit as setup
        this.myCheckingAccount.deposit(100);

        //try to make fast withdrawal
        try {
            this.myCheckingAccount.fastWithDraw();
        } catch (Exception e) {
            // TODO Auto-generated catch block
            e.printStackTrace();
        }

        //check balance
        assertEquals(40, this.myCheckingAccount.getBalance());
```

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## Create BankAccountTest Class

```java
        //set new fast cash amount
        this.myCheckingAccount.setFastCashAmount(20);

        //try to make fast withdrawal
        //doesn't expect Exception (error)
        assertDoesNotThrow(() -> {
            this.myCheckingAccount.fastWithDraw();
        });

        //check balance
        assertEquals(20, this.myCheckingAccount.getBalance());

        //set new fast cash amount < 0
        //should ignore this
        this.myCheckingAccount.setFastCashAmount(-50);

        //try to make fast withdrawal
        //doesn't expect Exception (error)
        assertDoesNotThrow(() -> {
            this.myCheckingAccount.fastWithDraw();
        });

        //check balance
        //should still default to $20 fast cash
        assertEquals(0, this.myCheckingAccount.getBalance());

        //make fast withdrawal
        //expects Exception (error)
        assertThrows(Exception.class, () -> {
            this.myCheckingAccount.fastWithDraw();
        });
    }
```

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