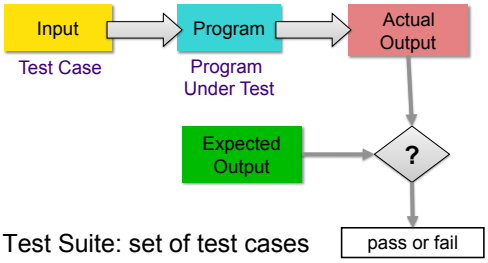
Objectives

- Testing
- Unit testing
- JUnit Framework
  - In Eclipse

Review

- Start Eclipse for later exercise
- Describe and compare the two software development models we discussed
- How can we categorize prototypes?
  - What are their characteristics?
- Describe the general testing process
- What is a set of test cases called?

Review: Software Testing Process



- Test Suite: set of test cases

Types of Testing

- Black-box testing
  - Test *functionality* (e.g., the calculator)
  - No knowledge of the code
  - Examples of testing: boundary values
- White-box testing
  - Have access to code
  - **Goal**: execute *all* code
- Non-functional testing
  - Performance testing
  - Usability testing (HCI)
  - Security testing
  - Internationalization, localization
- Acceptance testing
  - If customer accepts the product

Levels of Testing

- Unit
  - Tests minimal software component, in isolation
  - For us, Class-level testing
  - Web: Web pages (Http Request)
- Integration
  - Tests interfaces & interaction of classes
- System
  - Tests that completely integrated system meets requirements
- System Integration
  - Test system works with other systems, e.g., third-party systems

UNIT TESTING

Why Unit Test?

- Verify code works as intended in isolation
- Find defects ***early*** in development
  - Easier to test small pieces
  - Less cost than at later stages

Levels of Testing: Costs

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Why Unit Test?

- Verify code works as intended in isolation
- Find defects ***early*** in development
  - Easier to test small pieces
  - Less cost than at later stages
- As application evolves, new code is more likely to break existing code
  - Suite of (small) test cases to run after code changes
  - Also called **regression** testing

Some Approaches to Testing Methods

- Typical case
  - Test typical values of input/parameters
- Boundary conditions
  - Test at boundaries of input/parameters
  - Many bugs live "in corners"
- Parameter validation
  - Verify that parameter and object bounds are documented and checked
  - Example: pre-condition that parameter isn't null

➥ All black-box testing approaches

Another Use of Unit Testing: Test-Driven Development

- A development style, evolved from Extreme Programming
- Idea: write tests first, *without code bias*
- How it works:
  - Write the tests that the code/new functionality should pass
    - Like a specification for the code (pre/post conditions)
    - All tests will initially fail
  - Write the new code and make sure that it passes all test cases

Software Testing Issues

- How should you test? How often?
  - Code may change frequently
  - Code may depend on others' code
  - A lot of code to validate
- How do you know that an output is correct?
  - Complex output
  - Human judgment?
- What caused a code failure?

➥ Need a *systematic*, *automated*, *repeatable* approach

Characteristics of Good Unit Testing

Why would these be characteristics of good (unit) testing?

- **Automatic**
- **Thorough**
- **Repeatable**
- **Independent**

Characteristics of Good Unit Testing

- **Automatic**
  - Since unit testing is done frequently, don't want humans slowing the process down
  - Running test cases
  - Evaluating results
  - Input: in test itself or from a file
- **Thorough**
  - Covers all code/functionality/cases
- **Repeatable**
  - Reproduce results (correct, failures)
- **Independent**
  - Test cases are independent from each other
  - Easier to trace fault to code

JUNIT

JUnit Framework

- A framework for unit testing Java programs
  - Supported by Eclipse and other IDEs
  - Developed by Erich Gamma and Kent Beck
- Functionality
  - Write tests
    - Validate output, automatically
  - Automate execution of test suites
  - Display pass/fail results of test execution
    - Stack trace where fails
  - Organize tests, separate from code
- But, you still need to come up with the tests!

Testing with JUnit

- Typical organization:
  - Set of testing classes
  - Testing classes packaged together in a **`tests`** package
    - Separate package from code testing
- A test class typically
  - Focuses on a specific class
  - Contains methods, each of which represents another test of the class

```
tests
  └ CDTest
    DVDTest
    MediaItemTest
```


Structure of a JUnit Test

1. Set up the test case (optional)
   - Example: Creating objects
2. Exercise the code under test
3. Verify the correctness of the results
4. Teardown (optional)
   - Example: reclaim created objects

Annotations

- Testing in JUnit 4: uses **annotations**
- Provide data about a program that is not part of program itself
- Have no direct effect on operation of the code
- Example uses:
  - @Override: method declaration is intended to override a method declaration in parent class
    - If method does not override parent class method, compilers generates error message
  - Information for the compiler to suppress warnings (@SupressWarnings)

Tests are Methods

- Mark your testing method with `@Test`
  - From `org.junit.Test`

```
public class CalculatorTest {

    @Test
    public void add() {
        …
    }
}
```

Class for testing the Calculator class

A method to test the "add" functionality

- Convention: Method name describes what you're testing

Assert Methods

- Variety of assert methods available
- If fail, throw an exception
- All `static void`
- Example:
  `assertEquals(Object expected, Object actual)`

```
@Test
public void add() {
    …
    assertEquals(4, calculator.add(3, 1));
}
```


Assert Methods

- To use asserts, need *static* import:

```
import static org.junit.Assert.*;
```

  - `static` allows us to not have to use classname
- More examples
  - `assertTrue(boolean condition)`
  - `assertSame(Object expected, Object actual)`
    - Refer to same object

```
@Test
public void testEmptyCollection() {
   Collection collection = new ArrayList();
   assertTrue(collection.isEmpty());
}
```


Set Up/Tear Down

- May want methods to set up objects for every test in the class
  - Called **fixtures**
  - If have multiple, no guarantees for order executed

```
@Before
public void prepareTestData() { ... }

@Before
public void setupMocks() { ... }

@After
public void cleanupTestData() { ... }
```

Executed before **each** test method

Set Up/Tear Down For Class

- May want methods to set up objects for set of tests
  - Executed once before any test in class executes

```
@BeforeClass
public static void
setupDatabaseConnection() { ... }

@AfterClass
public static void
teardownDatabaseConnection() { ... }
```

JUNIT IN ECLIPSE

Using JUnit in Eclipse

- Eclipse can help make our job easier
  - Automatically execute tests (i.e., methods)
  - We can focus on coming up with tests

Using JUnit in Eclipse

- In Eclipse, go to your `MediaItems` project
- Create a new JUnit Test Case (under Java)
  - Use JUnit 4
    - Add junit to build path
  - Put in package `media.tests`
  - Name: `DVDTest`
  - Choose to test DVD class
    - Select `setUp` and `tearDown`
    - Select methods to test
- Run the class as a JUnit Test Case

Example

- Test method that gets the length of the DVD
  - Revise: Add code to `setUp` method that creates a DVD
- Notes
  - Replaying all the test cases: right click on package
  - FastView vs Detached
  - Hint: CTL-Spacebar to get auto-complete options

Unit Testing & JUnit Summary

- Unit Testing: testing smallest component of your code
  - For us: class and its methods
- JUnit provides framework to write test cases and run test cases automatically
  - Easy to run again after code changes
- JUnit Resources available from Course Page's "Resource" Link, under Java
  - API
  - Tutorials

Project 1: Testing Practice

- Due next Friday
- Given: a `Car` class that only has enough code to compile
- Your job: Create a ***good*** set of test cases that ***thoroughly***/***effectively*** test `Car` class
  - Find faults in my faulty version of `Car` class
  - Start: look at code, think about how to test, set up JUnit tests
  - Written analysis of process