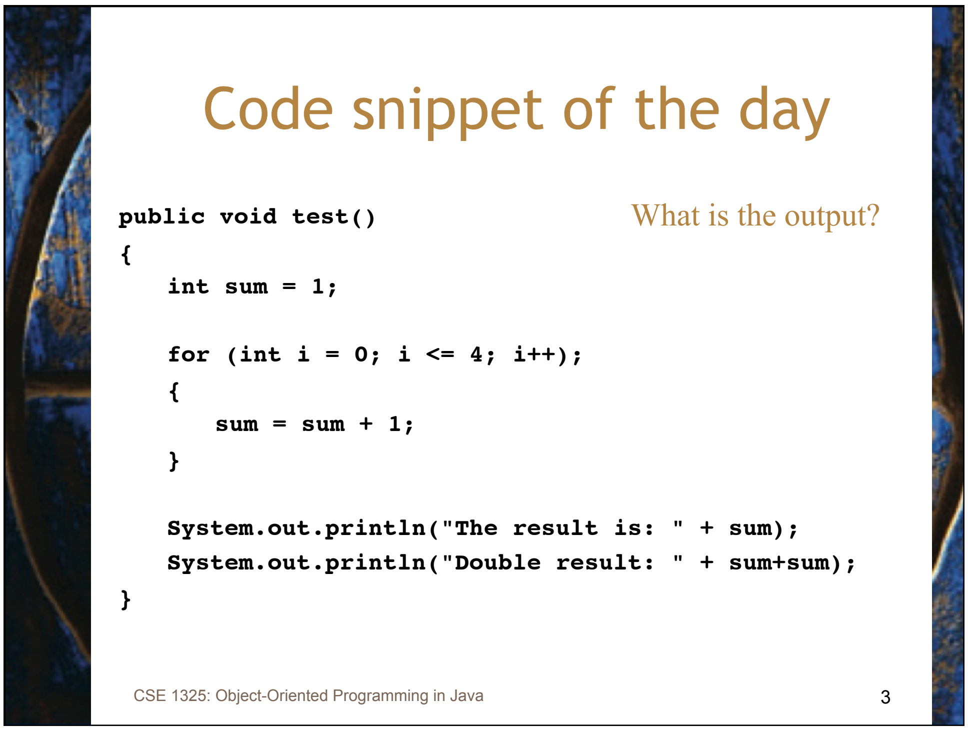
Well-behaved objects

Main concepts to be covered

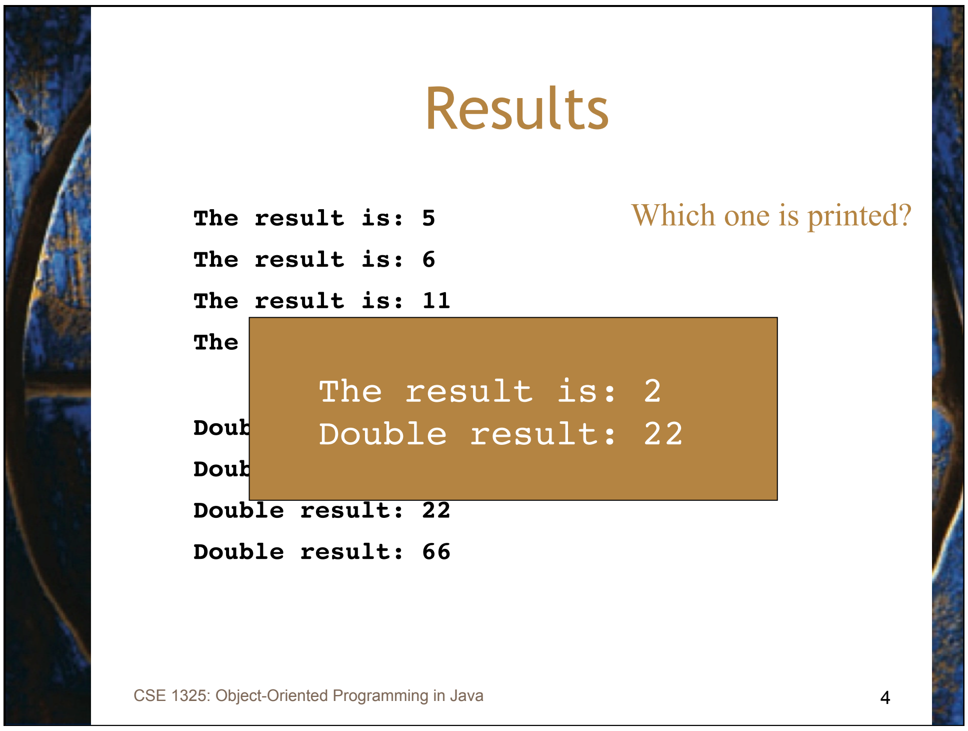
- Testing
- Debugging
- Test automation
- Writing for maintainability



Code snippet of the day

What is the output?

```
public void test()
{
    int sum = 1;

    for (int i = 0; i <= 4; i++);
    {
        sum = sum + 1;
    }

    System.out.println("The result is: " + sum);
    System.out.println("Double result: " + sum+sum);
}
```



Results

Which one is printed?

```
The result is: 5
The result is: 6
The result is: 11
The

Doub
Doub
Double result: 22
Double result: 66
```

```
The result is: 2
Double result: 22
```

Code snippet of the day

```
public void test()
{
    int sum = 1;

    for (int i = 0; i <= 4; i++);
    {
        sum = sum + 1;
    }

    System.out.println("The result is: " + sum);
    System.out.println("Double result: " + sum+sum);
}
```

We have to deal with errors

- Early errors are usually *syntax errors*.
  - The compiler will spot these.
- Later errors are usually *logic errors*.
  - The compiler cannot help with these.
  - Also known as bugs.
- Some logical errors have no immediately obvious manifestation.
  - Commercial software is rarely error free.

Prevention vs Detection (Developer vs Maintainer)

- We can lessen the likelihood of errors.
  - Use software engineering techniques, like encapsulation.
- We can improve the chances of detection.
  - Use software engineering practices, like modularization and documentation.
- We can develop detection skills.

Testing and debugging

- These are crucial skills.
- Testing searches for the presence of errors.
- Debugging searches for the source of errors.
  - The manifestation of an error may well occur some 'distance' from its source.

Testing and debugging techniques

- Unit testing (within BlueJ)
- Test automation
- Manual walkthroughs
- Print statements
- Debuggers

Unit testing

- Each unit of an application may be tested.
  - Method, class, module (package in Java).
- Can (should) be done during development.
  - Finding and fixing early lowers development costs (e.g. programmer time).
  - A test suite is built up.

Testing fundamentals

- Understand what the unit should do – its *contract*.
  - You will be looking for violations.
  - Use positive tests and negative tests.
- Test *boundaries*.
  - Zero, One, Full.
    - Search an empty collection.
    - Add to a full collection.

Well-behaved objects

Test automation

Main concepts to be covered

- Unit testing
- JUnit
- Regression testing
- Test cases
- Test classes
- Assertions
- Fixtures

Unit testing within BlueJ

- Objects of individual classes can be created.
- Individual methods can be invoked.
- Inspectors provide an up-to-date view of an object’s state.
- Explore through the *diary-prototype* project.

Test automation

- Good testing is a creative process, but ...
- ... thorough testing is time consuming and repetitive.
- *Regression testing* involves re-running tests.
- Use of a *test rig* or *test harness* can relieve some of the burden.
  - Classes are written to perform the testing.
  - Creativity focused in creating these.

Test automation

- Explore through the *diary-testing* project.
  - Human analysis of the results still required.
- Explore fuller automation through the *diary-test-junit* projects.
  - Intervention only required if a failure is reported.

JUnit

- JUnit is a Java test framework
- Test cases are methods that contain tests
- Test classes contain test methods
- Assertions are used to assert expected method results
- Fixtures are used to support multiple tests

Well-behaved objects

Debugging

Prevention vs Detection
(Developer vs Maintainer)

- We can lessen the likelihood of errors.
  - Use software engineering techniques, like encapsulation.
- We can improve the chances of detection.
  - Use software engineering practices, like modularization and documentation.
- We can develop detection skills.

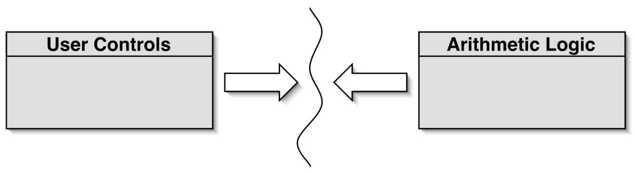
Debugging techniques

- Manual walkthroughs
- Print statements
- Debuggers

Modularization and interfaces

- Applications often consist of different modules.
  - E.g. so that different teams can work on them.
- The *interface* between modules must be clearly specified.
  - Supports independent concurrent development.
  - Increases the likelihood of successful integration.

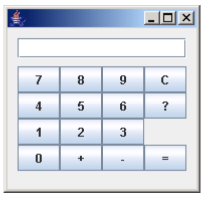
Modularization in a calculator



- Each module does not need to know implementation details of the other.
  - User controls could be a GUI or a hardware device.
  - Logic could be hardware or software.

Method signatures as an interface

```
// Return the value to be displayed.
public int getDisplayValue();

// Call when a digit button is pressed.
public void numberPressed(int number);

// Call when a plus operator is pressed.
public void plus();

// Call when a minus operator is pressed.
public void minus();

// Call to complete a calculation.
public void equals();

// Call to reset the calculator.
public void clear();
```



Debugging

- It is important to develop code-reading skills.
  - Debugging will often be performed on others' code.
- Techniques and tools exist to support the debugging process.
- Explore through the *calculator-engine* project.

Manual walkthroughs

- Relatively underused.
  - A low-tech approach.
  - More powerful than appreciated.
- Get away from the computer!
- ‘Run’ a program by hand.
- High-level (Step) or low-level (Step into) views.

Tabulating object state

- An object’s behavior is usually determined by its state.
- Incorrect behavior is often the result of incorrect state.
- Tabulate the values of all fields.
- Document state changes after each method call.

Verbal walkthroughs

- Explain to someone else what the code is doing.
  - They might spot the error.
  - The process of explaining might help you to spot it for yourself.
- Group-based processes exist for conducting formal walkthroughs or *inspections*.

Print statements

- The most popular technique.
- No special tools required.
- All programming languages support them.
- Only effective if the right methods are documented.
- Output may be voluminous!
- Turning off and on requires forethought.

Choosing a test strategy

- Be aware of the available strategies.
- Choose strategies appropriate to the point of development.
- Automate whenever possible.
  - Reduces tedium.
  - Reduces human error.
  - Makes (re)testing more likely.

Debuggers

- Debuggers are both language- and environment-specific.
  - BlueJ has an integrated debugger.
- Support breakpoints.
- Step and Step-into controlled execution.
- Call sequence (stack).
- Object state.

Review

- Errors are a fact of life in programs.
- Good software engineering techniques can reduce their occurrence.
- Testing and debugging skills are essential.
- Make testing a habit.
- Automate testing where possible.
- Practice a range of debugging skills.

Acknowledgement

The original authors of these slides are the authors of the textbook. The instructor made necessary modifications, with permissions from the authors.