CS18000: Problem Solving and Object-Oriented Programming

Methods and Classes
Video 1
Static and Non-Static Fields
Methods and Classes

Defining Methods
Parameters
Return Values
Java Class

• Java class includes...
  – Fields: attributes of an object or the class
  – Methods: operations on an object or the class

• Within certain limitations:
  Fields are accessible to methods of the class

• Fields and methods may be static or non-static
  – When static, fields and methods are “of the class”
  – When non-static, fields and methods are “of the object”
Static and Non-Static Fields

• **Static field:**
  – One memory location shared by all objects of the class
  – Same value shared by all methods
  – What is this good for?

• **Non-static field:**
  – Each instance of the class (object) has its own memory location for the field
  – Different value (in general) in each object
Java Terminology: Variables

• *Instance variables*: non-static fields in a class declaration
• *Class variables*: static fields in a class declaration
• *Local variables*: variables in method or block
• *Parameters*: variables in a method declaration

Source: http://docs.oracle.com/javase/tutorial/java/nutsandbolts/variables.html
Problem: Counter

• Create a class with static and non-static counters
• Create objects
• Increment the counters
• Print values before and after
Solution 1: Counter

```java
public class Counter {
    int x;
    static int y;

    public static void main(String[] args) {
        Counter alice = new Counter();
        Counter bob = new Counter();

        alice.x = 10; alice.y = 42;
        bob.x = 50; bob.y = 99;

        System.out.println(alice.x); System.out.println(alice.y);
        System.out.println(bob.x); System.out.println(bob.y);

        alice.y++;
        System.out.println(alice.y); System.out.println(bob.y);

        System.out.println(alice.y); System.out.println(bob.y);
        bob.y++;
        System.out.println(alice.y); System.out.println(bob.y);
    }
}
```
Solution 1: Counter

Counter

dlice

bob
Video 2
Methods
Methods

• Method: a parameterized block of code that may return a value
• Every method exists inside some class
• Useful for...
  – Reusability: Reduce redundancy in code
  – Readability: Identify logical operation by name (abstraction)
  – Modularity: software developers can code and test independently
Basic Method Syntax

```java
return_type methodName(param_list) {
    statements;
    return_if_needed;
}
```

- **return_type**: type of value to be returned (void if no return value)
- **param_list**: list of parameters expected by method (includes types and local name, can be empty)
Parameters and Arguments

• Parameters allow a method to work on different data values
• Parameter: a variable local to a method
• Argument: an expression that is passed to the corresponding parameter at time of method call
• Argument values are copied into parameter variables
• Argument values to a method must match the number and types of parameters of the method

```java
int calc (double x, int y) {… return z;} 
sum = calc (r,s);
```
Parameters and Arguments

```plaintext
main
double r 21.46
int s 15
int sum

calc (double x, int y)
double x
int y
int z

sum = calc (r, s);
```
Flow of Control for Method Calls

• Before call: argument values at calling site are copied to parameter variables in called method

• Then...
  – The calling method is “suspended”
  – The called method begins at the top of the method body and runs to completion (return statement or the end)
    – The calling method continues where it left off

• After call: Return value from called method becomes value returned to calling site
Parameters: Call by Value

• Parameter variables are distinct from variables passed in as arguments

```java
void changer(int x) {
    x = 12;
}
...

int y = 5;
changer(y);
System.out.println(y); // prints 5
```
Parameters: Call by Value

```
main
int y = 5
changer (y);
```

```
changer (int x)
int x
```
public class Counter {
    int x;
    static int y = 42;

    Counter(int x) {
        this.x = x;
    }

    public static void main(String[] args) {
        Counter alice = new Counter(100);
        Counter jimmy = new Counter(500);

        System.out.printf("%s: x = %d, y = %d\n", "alice", alice.x, alice.y);
        System.out.printf("%s: x = %d, y = %d\n", "jimmy", jimmy.x, jimmy.y);

        alice.x++;
        alice.y++;
        jimmy.x++;
        jimmy.y++;

        System.out.printf("%s: x = %d, y = %d\n", "alice", alice.x, alice.y);
        System.out.printf("%s: x = %d, y = %d\n", "jimmy", jimmy.x, jimmy.y);
    }
}
Solution 3: Counter

public class Counter {

    // [fields and constructor omitted]

    static void display(String name, Counter c) {
        System.out.printf("%s: x = %d, y = %d\n", name, c.x, c.y);
    }

    public static void main(String[] args) {
        Counter alice = new Counter(100);
        Counter jimmy = new Counter(500);

        display("alice", alice);
        display("jimmy", jimmy);

        alice.x++;
        alice.y++;
        jimmy.x++;
        jimmy.y++;

        display("alice", alice);
        display("jimmy", jimmy);
    }
}
Video 3
Scope of Variables
Static and Non-Static Methods

• **Static method:**
  – May only access static fields and call other static methods in the class
  – Can be called using class name: Math.pow(2, 5)

• **Non-static method:**
  – May also access non-static fields associated with the particular object
  – Must be associated with an object in some way in order to be called, e.g., t3.describe()
  – If no object specified, “this” implied: describe() is same as this.describe()
Extended Method Syntax

\[
[\text{static}] \text{ return_type methodName(} \text{param_list})
\{
    \text{statements;}
    \text{return\_if\_needed;}
\}
\]

• \textit{static}: method is a static method
• Not \textit{static}: method is an “instance method” (AKA “object method”)
Constructors

Counter c1 = new Counter(500);

• Not exactly a method, but very similar
• Callable using “new” operator
• May take parameters
• May access all fields of class (including static)
• Main task: Initialize the object being allocated
• Does not explicitly return a value...
• ...but the new operator that started it returns a reference to the newly created object
Scope of Variables

• Scope: where in the code the variable is usable

• Basic rule: A variable is usable from the point of declaration to the end of the enclosing block

• Special cases...
  – Parameters: accessible within the method body
  – For loop variable: accessible within heading and body
Example: Scope1a

```java
public class Scope1 {
    int x;

    void one(int x) { // OK: hides field x
        //      int x; // cannot have in same scope as parameter
    }

    void two() {
        int x = 10; // OK: hides field x

        while (true) {
            //          int x; // error: same scope as x above
        }
    }
}
```
Example: Scope1b

```java
public class Scope1 {

    public static void main(String[] args) {
        { // independent block 1
            int x = 12;
        }

        { // independent block 2
            int x = 15;
        }

        for (int i = 0; i < 10; i++)  // i is available in header and body
            System.out.println(i);

        //     System.out.println(i);  // i is now "out of scope"
    }
}
```
Limitations Because of Scope Rules

• Cannot have two variables with same name active in same scope (compiler gives a syntax error)

• Exception:
  – parameters and local variables can “shadow” (hide) fields with the same name
  – Use this.field to access hidden field

• You’ve seen this used in many constructors
public class Scope2 {
    int x;
    String name;

    Scope2(int x, String aName) {
        this.x = x;  // common style to initialize a field
        name = aName;  // alternative style that doesn't require 'this'
    }

    void doit() {
        int x = 10;  // OK: hides field x

        this.x = x;  // allows access to hidden field x
    }

    public static void main(String[] args) {
        Scope2 sc1 = new Scope2(12, "Fred");
        Scope2 sc2 = new Scope2(25, "Ralph");
    }
}
What is this anyway?

• Java reserved word...
• ...cannot have a variable named “this”
• Used only within a non-static method or constructor
• It is a reference to the “current object”
• Used to access any field or method (member) of the current object
Video 1
Designing a Class
When designing a class... (1)

• Non-static fields are the attributes of the objects of the class
  – Wheel diameter
  – Tree circumference
  – Puzzle matrix

• Static fields are shared by all objects of the class
  – Constants
  – Totals or other variables that accumulate across all objects
When designing a class... (2)

• Non-static methods operate on the attributes of the class (think: “do an action on/with object”)
  – computeDiameter
  – computeSolution

• Static methods operate on static variables or use no non-local variables at all
  – readPuzzle, readWords, computeSqrt
  – Utility methods: process parameters, return value
  – main method of a program
Problem: Modeling Trees

• Individual trees have a circumference
• Collectively, a number of trees (Tree objects) have been created (with new)
public class Tree {
    double circumference;
    static int numberOfTrees = 0;

    Tree(double circumference) {
        this.circumference = circumference;
        numberOfTrees = numberOfTrees + 1;
    }

    double getRadius() {
        return circumference / (2 * Math.PI);
    }

    static int getNumberOfTrees() {
        return numberOfTrees;
    }
}
Problem: Making Trees

• Write a program to create a number of trees
• Print how many trees were created
• Could use a counter in the method(s) that create a new Tree...
• ... but using a Tree static variable keeps the bookkeeping centralized without having to insert the same code in all places that create a Tree
• Math.random() returns a number from [0.0 to 1.0)
public class TreeMaker {
    public static void main(String[] args) {
        while (Math.random() < 0.9) {
            Tree t = new Tree(Math.random() * 100);
            System.out.printf("tree has radius %.3f\n", t.getRadius());
        }
        System.out.printf("created %d trees\n", Tree.getNumberOfTrees());
    }
}
Video 2
Extent, Passing References, Overloading
Methods and Classes

Extent, Passing References, Overloading
Encapsulation
Accessors and Mutators
Extent (vs. Scope)

• Scope: Where a variable is “visible”
• Extent: How long a value is kept (its “lifetime”)
• Variable: lifetime same as scope
  – When block left, value of variable is lost
  – So, initializers are re-done on block entry
    – while (...) { int i = 0; i++; System.out.println(i); }
• Object: lifetime lasts until it is no longer accessible (e.g., no variables reference it)
Extent (vs. Scope)

```java
String s = new String ("Purdue");
```

```java
String t = s;  
```

```java
s = new String ("Indiana");
```

```java
t = new String ("Ball State");
```
Passing References by Value

• Reminder: parameter passing is “by value”
• Passing an object reference by value means...
  – The “value” is the reference to (address of) the object
  – The called method cannot modify the variable where the reference is stored
  – But, it can modify the object it references
Example: Reference by Value

```java
public class Danger {
    static void modify(Wheel wagon) {
        wagon.radius = 22.6; // modifies object referenced by wagon
    }

    public static void main(String[] args) {
        Wheel w = new Wheel(17.5);

        System.out.println(w.getRadius());

        modify(w);

        System.out.println(w.getRadius());
    }
}
```
Example: Reference by Value

<table>
<thead>
<tr>
<th>main</th>
<th>modify (Wheel wagon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{w} \rightarrow \text{radius 17.5}</td>
<td>\text{wagon } \square</td>
</tr>
</tbody>
</table>

\text{modify (w);}
Overloading Constructors and Methods (1)

• Term *signature* refers to the name and parameter types of a method or constructor
  
  \[
  \text{double getPayment (int months, double interestRate)}
  \]

• Each constructor and method in a class must have a unique signature

• Same names are OK, but parameter types must be different

  \[
  
  \begin{align*}
  \text{double getPayment (int years)} \\
  \text{double getPayment ()} \\
  \text{double getPayment (int owner, String address)}
  \end{align*}
  \]
Overloading Constructors and Methods (2)

• Java matches argument types with parameter types to choose the right constructor or method to invoke

• Called *overloading*: we’re overloading the meaning of the method name

• Many built-in classes use constructor and method overloading (see `println` in [http://docs.oracle.com/javase/6/docs/api/java/io/PrintStream.html](http://docs.oracle.com/javase/6/docs/api/java/io/PrintStream.html))
public class Palindrome {
    static boolean isPalindrome(String s) {
        if (s == null || s.length() <= 1)
            return true;

        while (s.length() > 1) {
            char first = s.charAt(0);
            char last = s.charAt(s.length() - 1);
            if (first != last)
                return false;
            s = s.substring(1, s.length() - 1);
        }
        return true;
    }

    static boolean isPalindrome(int x) {
        return isPalindrome(Integer.toString(x));
    }
}
Video 3
this() in Constructors
Special Trick: `this()` in Constructor

- Use `this(...)` to invoke one constructor from another
- Must be first line in current constructor
- Java matches argument types to determine which constructor to call
- Other constructor returns to calling constructor
public class PurdueStudent {
    boolean hasName;
    String name;
    int puid;

    // constructor with int...
    PurdueStudent(int puid) {
        this.puid = puid;
        hasName = false;
    }

    // constructor with String and int...
    PurdueStudent(String name, int puid) {
        this(puid);
        this.name = name;
        hasName = true;
    }

    // [see next slide...]
}
public class PurdueStudent {
    // [see previous slide…]
    
    void printStudent() {
        if (hasName)
            System.out.println(name + " : " + puid);
        else
            System.out.println("(no name): " + puid);
    }

    public static void main(String[] args) {
        // call int-only constructor...
        PurdueStudent p1 = new PurdueStudent(1010337138);

        // call String-int constructor...
        PurdueStudent p2 = new PurdueStudent("Drake", 1123441245);

        p1.printStudent();
        p2.printStudent();
    }
}
public class Overloader {
    int calc (double x, int y) {
        ...
        return z;
    }
    // valid overload, 3 parameters
    int calc (double x, int y, int z) {
        ...
        return z;
    }
    // valid overload, 1 parameter
    double calc (double x) {
        ...
        return q;
    }
    // valid overload, 2 parameters, different types
    int calc (double x, String s) {
        ...
        return z;
    }
    // INVALID overload, return type is not part of the signature
    double calc (double a, int b) {
        ...
        return q;
    }
}
Video 4
Encapsulation
Encapsulation

• Java supports team work through encapsulation
• A form of information hiding or “need to know”
• Encapsulation serves two purposes
  – Hides implementation details from other programmers, allowing the author to make changes without affecting other programmers
  – Prevents other programmers from modifying certain fields or calling certain methods that might leave the object in an inconsistent or unexpected state
Java Access Modifiers

• Can apply to members: fields and methods
• Modifiers control access to members from methods in other classes
• This list is from least to most restrictive:

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>public</td>
<td>None (any other method can access)</td>
</tr>
<tr>
<td>protected</td>
<td>Only methods in the class, subclasses, or in classes in the same package can access</td>
</tr>
<tr>
<td>[none]</td>
<td>Only methods in the class or in classes in the same package can access (called “package private”)</td>
</tr>
<tr>
<td>private</td>
<td>Only methods in the class can access</td>
</tr>
</tbody>
</table>
Conventional Wisdom

• Make methods public
  – Allows anyone to use them
  – They should be written defensively to “protect” the object internal state (i.e., attribute fields)

• Make fields private
  – Keeps them safe from unexpected changes
  – Only your methods can modify them

• Constants ("final" fields) can be made public since they can’t be changed anyway
Accessor and Mutator Methods

• With fields being private, all access to them from outside the class is via methods

• There is no special Java syntax, just naming convention:
  – Accessor: “get…” access (read) field in an object
  – Mutator: “set…” mutate (change) field in an object

• Accessor methods allow read-only access

• Mutator methods allow “controlled” change
public class Wheel {
    private double radius;
    public Wheel(double radius) {
        this.radius = radius;
    }
    public double getCircumference() {
        return 2 * Math.PI * radius;
    }
    public double getArea() {
        return Math.PI * radius * radius;
    }
    public double getRadius() {
        return radius;
    }
    public void setRadius(double r) {
        if (r>0 && r<=1000)
            radius=r;
    }
}
Using Accessor and Mutator Methods

public class Transportation {

    public static void main(String[] args) {
        Wheel w = new Wheel(17.5);

        double circ = w.getCircumference();

        double rad = w.radius;  // not allowed
        double rad = w.getRadius();

        w.radius = 15.4; // not allowed
        w.setRadius(15.4);
    }
}