Software Development (cs2500)

Lecture 18: Class Design

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November 1, 2013

Objectives

- Study methods and why they are useful.
- Learn the *pass-by-value rule.*
    - Describes how methods should be evaluated.
- Simulate the evaluation of methods.
- Write classes by carrying out a case study.

Why do we Need Methods?

- Methods are interfaces for parameterised computations.
- Method calls provide reusable computations.
- Building blocks of complex computations.
- Calls are the only mechanism to change `private` variables.
- Methods encapsulate computations.
  - Classes encapsulate method definitions.
  - This lets you hide the implementation.

Parameter Taxonomy

Formal parameter: A parameter in the method's definition.

Java

```
⟨visibility modifier⟩ ⟨static option⟩
⟨type⟩ ⟨method name⟩( ⟨type⟩₁ ⟨formal parameter⟩₁,
                           ...,
                           ⟨type⟩ₙ ⟨formal parameter⟩ₙ ) {
     ⟨body⟩
}
```

Actual parameter: A parameter in the method calls.

Java

```
⟨reference⟩.⟨method name⟩( ⟨actual parameter⟩₁,
                            ...,
                            ⟨actual parameter⟩ₙ );
```

Actual Parameters

Java

```
System.out.println( "The answer is " + 42 + "." );
```

Actual Parameters are Expressions

Java

```
System.out.println( "The answer is " + 42 + "." );
```

Example

Java

```
public static int f( int a, int b ) {
    return a + b;
}

public static void g( int c ) {
    int a = f( 1, 2 + c );
    int d = f( 1 + 3, a );
}
```

Example: Formal Parameters

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The Pass-by-Value Mechanism

Carrying out a Call with *n* Parameters

1. Create a fresh variable for each parameter.
2. For *i* from 1 to *n* (from left to right):
    1. Evaluate the *i*th actual parameter.
    2. Assign the result of the *i*th evaluation to the *i*th fresh variable.
3. Carry out statements in the method body.
4. Return result (if any).
5. Remove fresh variables.

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Storing the Value of a Temporary Variable

The Stack

- Actual parameter values are stored on the *stack*.
  - When method is called, variables are created on top of stack.
  - When method returns this scratch space is released.
- The stack is also used to represent local variables in blocks.
  - When block is entered, variable are created on top of the stack.
  - When control leaves the block this scratch space is released.

Example #1

Calling g(5)

Java

```
public static int f( int a ) {
    int b = a + 1;
    a = a + 2;
    return a * b;
}

public static void g( int b ) {
    int a = 1;
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    c = f( a + a );
    System.out.println( a + " " + c );
    // Prints: 1 12
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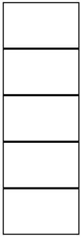

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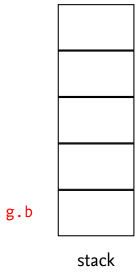

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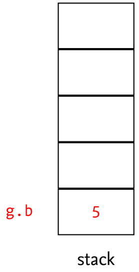

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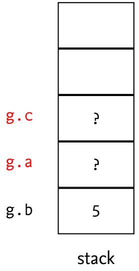

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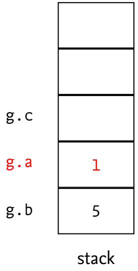

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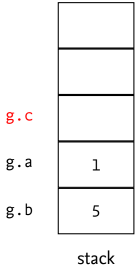

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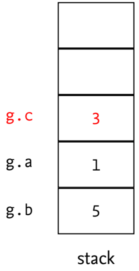

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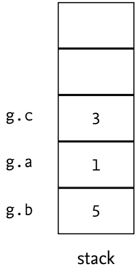

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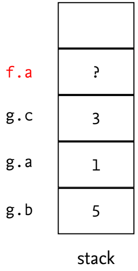

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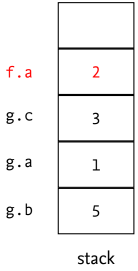

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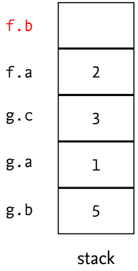

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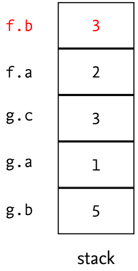

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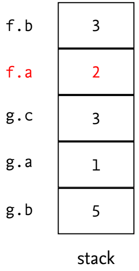

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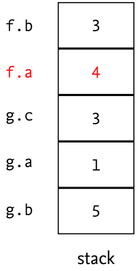

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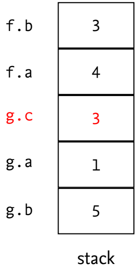

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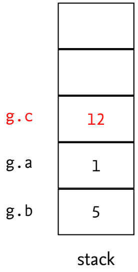

Example #2
Initial Call is `fib( 2 )`

Java

```
public static int fib( int n ) {
    if (n <= 1) {
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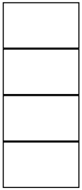
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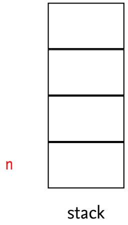

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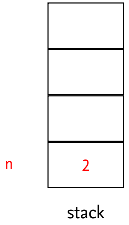

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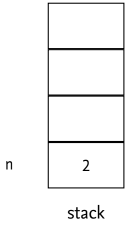

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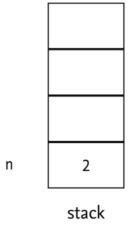

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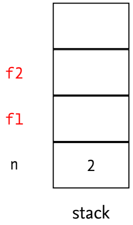

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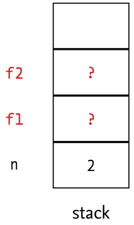

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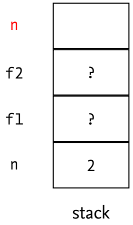

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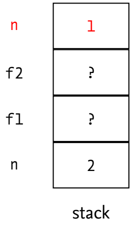

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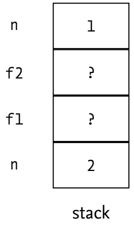

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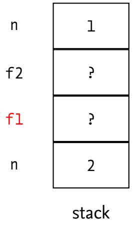

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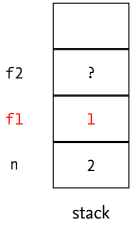

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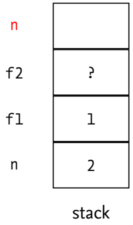

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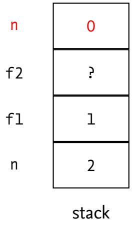
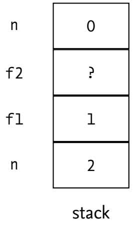


Example #2

Initial Call is `fib( 2 )`

Java

```
public static int fib( int n ) {
    if (n <= 1) {
        return 1;
    } else {
        int f1 = fib( n - 1 );
        int f2 = fib( n - 2 );
        return f1 + f2;
    }
}
```



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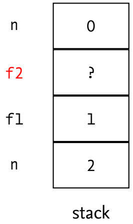

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Initial Call is `fib( 2 )`

Java

```
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        return 1;
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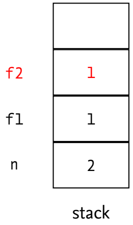
        return f1 + f2;
    }
}
```



Example #2

Initial Call is fib(2)

Java

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public static int fib( int n ) {
    if (n <= 1) {
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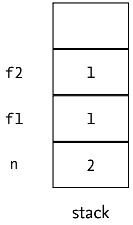


Example #3:

Java

```
public class Example {
   private int a;

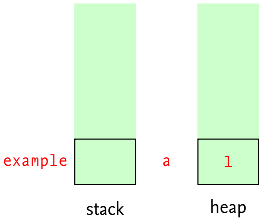
   public Example( ) {
      a = 1;
   }

   public static void main( String[] args ) {
      Example example = new Example( );
      example.g( );
   }

   public int f( int b ) {
      b = 2;
      a = 2;
      return a + b;
   }

   public void g( ) {
      int c = f( a );
      System.out.println( a + " " + c );

   }
}
```



Example #3: The JVM Creates an Object

Java

```
public class Example {
   private int a;

   public Example( ) {
       a = 1;
   }

   public static void main( String[] args ) {
       Example example = new Example( );
       example.g( );
   }

   public int f( int b ) {
      b = 2;
      a = 2;
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   }

   public void g( ) {
      int c = f( a );
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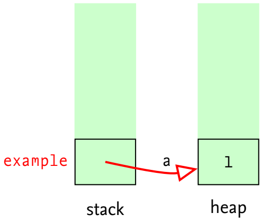
   }
}
```



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      int c = f( a );
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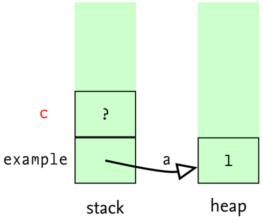
   }
}
```



Example #3:

Java

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public class Example {
   private int a;

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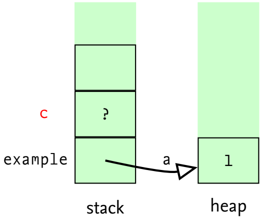

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   public int f( int b ) {
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      a = 2;
      return a + b;
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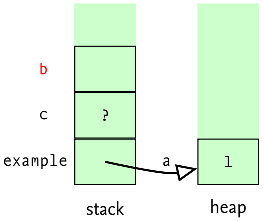

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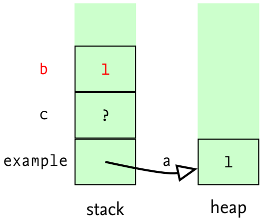

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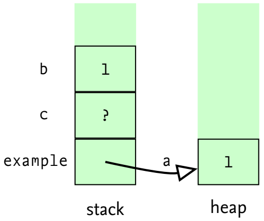

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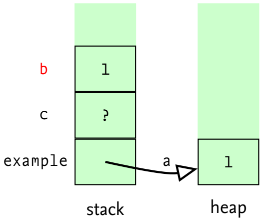

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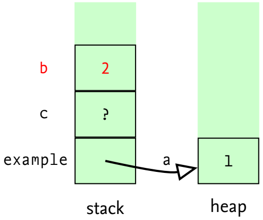

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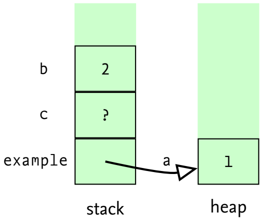

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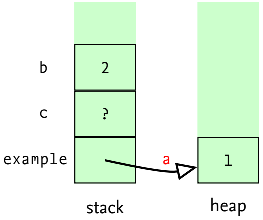

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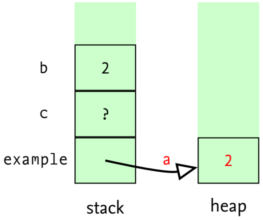

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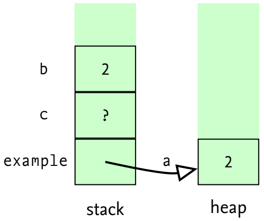

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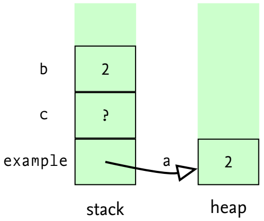

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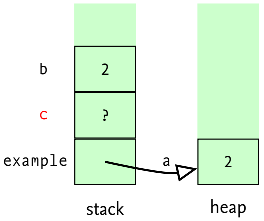

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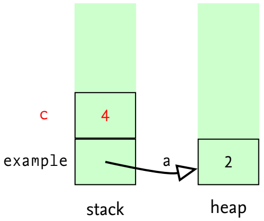

Example #3:

Java

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   private int a;

   public Example( ) {
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   }

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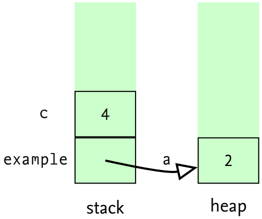
      b = 2;
      a = 2;
      return a + b;
   }

   public void g( ) {
      int c = f( a );
      System.out.println( a + " " + c );
      // Prints: 2 4.
   }
}
```



Class Design: How To?

- When we design an application, how do we choose the classes?
- Once we've decided on the classes,
  - How do we choose the attributes, and
  - How do we choose the methods?
- The answer is in the problem specification.

Clues

- To find classes: look for actors in the spec.
    - This works, because the actors correspond to the objects,
        - And each object is an instance of its class.
    - We may implement the object in a class named after the actor:
        - Toy and `Toy`;
        - Writer and `Writer`;
        - Dog and `Dog`;
        - ...
- The actors do things (verbs): these are the methods.
- The actors own things, these are the attributes.

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- The actors do things (verbs): these are the methods.
- The actors own things, these are the attributes.

Playing with Toys

- There are hands and toys;
- Toys are either used or free;
- Initially toys are free;
- Hands cannot take used toys;
- Hands can only take free toys;
- If a toy is taken by a hand it becomes used;
- A hand can drop its toy;
- Dropping a toy makes it free;
- Each toy has its own name; and
- Each hand has its own type: left or right.

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The Toy Class

How do we find the Attributes and Methods?

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The Toy Class

How do we find the Attributes and Methods? Look for Properties and (Active) Verbs.

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Java

```
public class Toy {
    private final String name;
    private boolean used;

    public Toy( String name ) {
        this.name = name;
        used = false;
    }

    // Getter and setter methods omitted.

    @Override
    public String toString( ) {
        return "Toy[ name = " + name + " ]";
    }
}
```

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The Hand Class

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The Hand Class

Java

```
public class Hand {
    private final String type;
    private Toy toy;

    public Hand( String type ) {
        this.type = type;
        toy = null;
    }

    public void take( Toy toy ) { ⟨to do⟩ }
    public void drop( ) { ⟨to do⟩ }
    // Getters and setters omitted.

    @Override
    public String toString( ) {
        return "Hand[ type = " + type + ", toy = " + toy + " ]";
    }
}
```

The take( ) Method

Java

```
public void take( Toy toy ) {









}
```

The take( ) Method

Java

```
public void take( Toy toy ) {

        // We cannot take a Toy if Hand is full.









}
```

The take( ) Method

Java

```
public void take( Toy toy ) {
    if (this.toy != null) {
        // We cannot take a Toy if Hand is full.
        System.err.println( "** " + this + " is full." );
        System.err.println( "** Cannot take " + toy + "." );
    }









}
```

The take( ) Method

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public void take( Toy toy ) {
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        // We cannot take a used Toy.








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public void take( Toy toy ) {
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        System.err.println( "** Cannot take " + toy + "." );
    } else if (toy.getUsed( )) {
        // We cannot take a used Toy.
        System.err.println( "** " + toy + " is taken." );
        System.err.println( "** Cannot take it." );
    }








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The take( ) Method

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public void take( Toy toy ) {
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    } else {
        // Take toy.





    }
}
```

The take( ) Method

Java

```
public void take( Toy toy ) {
    if (this.toy != null) {
        // We cannot take a Toy if Hand is full.
        System.err.println( "** " + this + " is full." );
        System.err.println( "** Cannot take " + toy + "." );
    } else if (toy.getUsed( )) {
        // We cannot take a used Toy.
        System.err.println( "** " + toy + " is taken." );
        System.err.println( "** Cannot take it." );
    } else {
        // Take toy.
        // Formally mark toy as used.
        toy.setUsed( true );
        // Make toy our current Toy.
        this.toy = toy;
    }
}
```

The take( ) Method

Java

```
public void take( Toy toy ) {
    if (this.toy != null) {
        // We cannot take a Toy if Hand is full.
        System.err.println( "** " + this + " is full." );
        System.err.println( "** Cannot take " + toy + "." );
    } else if (toy.getUsed( )) {
        // We cannot take a used Toy.
        System.err.println( "** " + toy + " is taken." );
        System.err.println( "** Cannot take it." );
    } else {
        // Take toy.
        // Formally mark toy as used.
        toy.setUsed( true );
        // Make toy our current Toy.
        this.toy = toy;
    }
}
```

The drop( ) Method

Java

```
public void drop( ) {








}
```

The drop( ) Method

Java

```
public void drop( ) {
        // We cannot drop a toy if we don’t have one.





}
```

The drop( ) Method

Java

```
public void drop( ) {
    if (toy == null) {
        // We cannot drop a toy if we don’t have one.
        System.err.println( "** " + this + " is empty." );
        System.err.println( "** Cannot drop any toy." );
    }





}
```

The drop( ) Method

Java

```
public void drop( ) {
    if (toy == null) {
        // We cannot drop a toy if we don’t have one.
        System.err.println( "** " + this + " is empty." );
        System.err.println( "** Cannot drop any toy." );
    } else {
        // Drop our current toy.




    }
}
```

The drop( ) Method

Java

```
public void drop( ) {
    if (toy == null) {
        // We cannot drop a toy if we don't have one.
        System.err.println( "** " + this + " is empty." );
        System.err.println( "** Cannot drop any toy." );
    } else {
        // Drop our current toy.
        // Formally mark toy as free.
        toy.setUsed( false );
        // Make hand empty.
        toy = null;
    }
}
```

The drop( ) Method

Java

```
public void drop( ) {
    if (toy == null) {
        // We cannot drop a toy if we don’t have one.
        System.err.println( "** " + this + " is empty." );
        System.err.println( "** Cannot drop any toy." );
    } else {
        // Drop our current toy.
        // Formally mark toy as free.
        toy.setUsed( false );
        // Make hand empty.
        toy = null;
    }
}
```

The `main`

Java

```
public static void main( String[] args ) {
    Hand left = new Hand( "left" );
    Hand right = new Hand( "right" );
    Toy game = new Toy( "computer game" );
    Toy puzzle = new Toy( "puzzle" );

    left.take( game );
    right.take( game ); // Results in error message
    right.take( puzzle );
    left.drop( );
    left.drop( );       // Results in error message
}
```

The main: Magic Constants

Java

```
public static void main( String[] args ) {
    Hand left = new Hand( "left" );
    Hand right = new Hand( "right" );
    Toy game = new Toy( "computer game" );
    Toy puzzle = new Toy( "puzzle" );

    left.take( game );
    right.take( game ); // Results in error message
    right.take( puzzle );
    left.drop( );
    left.drop( );       // Results in error message
}
```

The main: Constant Class Attributes

Java

```
private static final String LEFT = "left";
private static final String RIGHT = "right";
private static final String GAME = "computer game";
private static final String PUZZLE = "puzzle";

public static void main( String[] args ) {
    Hand left = new Hand( LEFT );
    Hand right = new Hand( RIGHT );
    Toy game = new Toy( GAME );
    Toy puzzle = new Toy( PUZZLE );

    left.take( game );
    right.take( game ); // Results in error message
    right.take( puzzle );
    left.drop( );
    left.drop( );       // Results in error message
}
```

For Monday

- Study the notes.
- Study Sections 7.1 and 7.2.

About this Document

- This document was created with `pdflatex`.
- The LaTeX document class is `beamer`.