CS/ENGRD 2110
Object-Oriented Programming and Data Structures

Fall 2012

Doug James

Lecture 2: Java Review

Academic Excellence Workshop

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CLASS TIME: Fridays 2:30PM-4:25PM HLS 401

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Join ISSA, the Information Science Student Association!
Come to our first meeting of 2012-13
THURSDAY (9/6) at 4:30pm in Upson Lounge
There will be pizza and soda!

Questions? Want to join our listserv?
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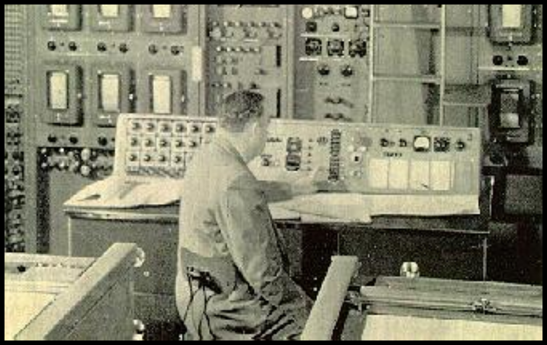
Outline

- A brief (biased) history of programming languages
- Review of some Java/OOP concepts
- Java tips, trick, and pitfalls

Machine Language

- Used with the earliest electronic computers (1940s)
  - Machines use vacuum tubes instead of transistors
- Programs are entered by setting switches or reading punch cards
- All instructions are numbers



- Example code

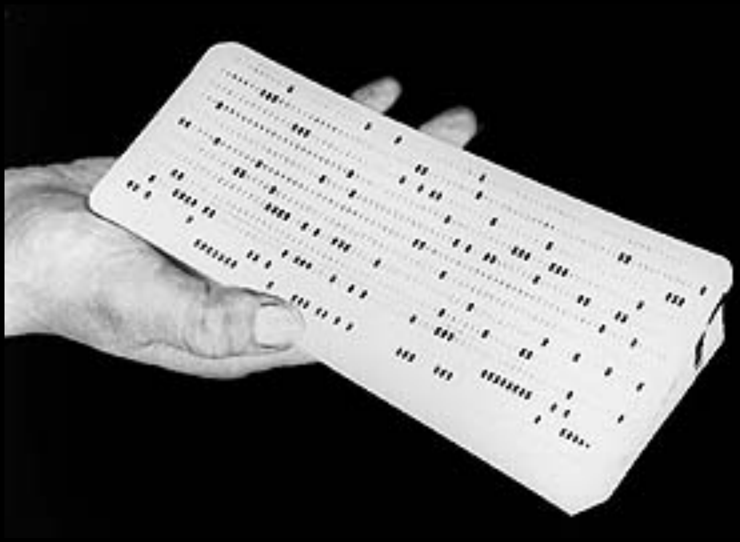
0110 0001 0000 0110

add reg1 6

- An idea for improvement
  - Use words instead of numbers
- Result: Assembly Language

Assembly Language

- **Idea:** Use a program (an *assembler*) to convert assembly language into machine code
- Early assemblers were some of the most complicated code of the time (1950s)



- Example code

  ADD R1 6

  MOV R1 COST

  SET R1 0

  JMP TOP

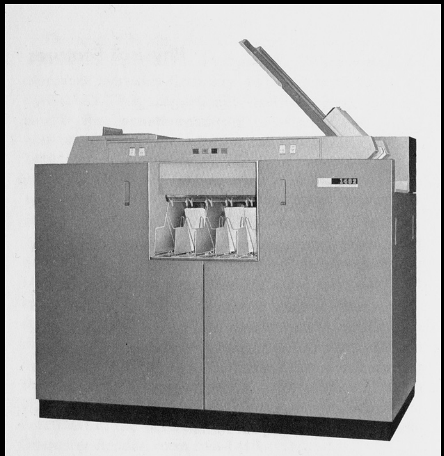


Figure 4. IBM 1402 Card Read-Punch

- Idea for improvement
  - Let's make it easier for humans by designing a high-level computer language
- Result: high-level languages

High-Level Language

- **Idea:** Use a program (a *compiler* or an *interpreter*) to convert high-level code into machine code
- **Pro**
  - Easier for humans to write, read, and maintain code
- **Con**
  - The resulting program will never be as efficient as good assembly-code
    - Waste of memory
    - Waste of time

- The whole concept was initially controversial
- FORTRAN (mathematical FORmula TRANslating system) was designed with efficiency very much in mind

FORTRAN

- Initial version developed in 1957 by IBM

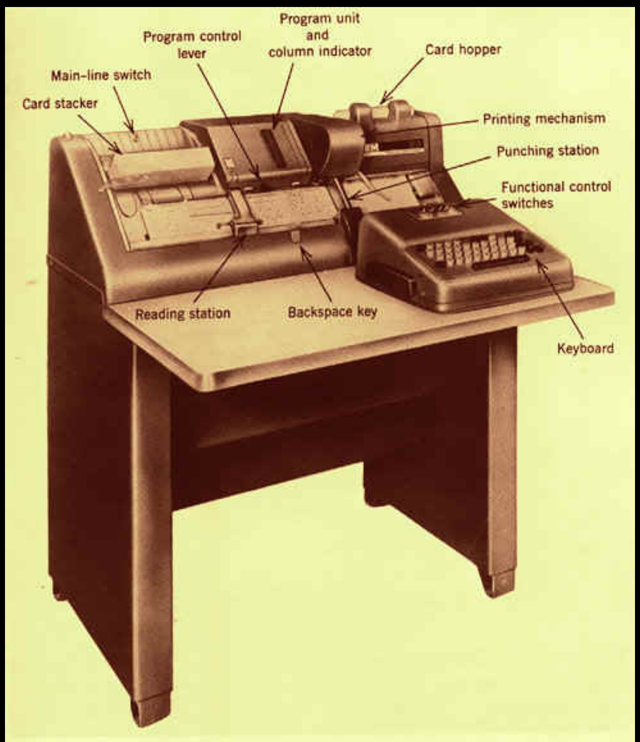


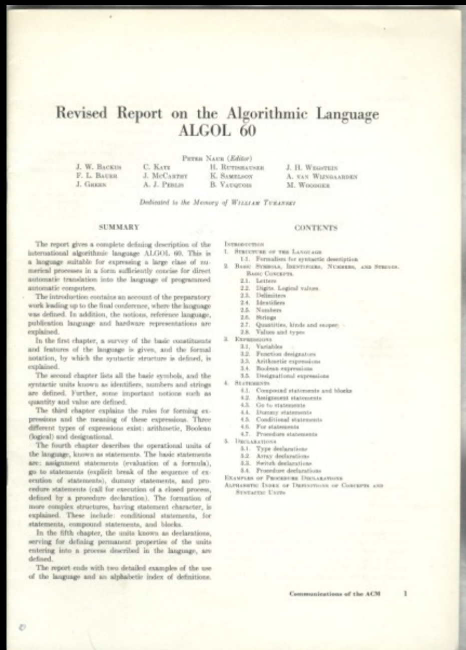
FIGURE 4.11 IBM 026 Keypunch (Courtesy IBM).

- Example code

```
C SUM OF SQUARES
      ISUM = 0
      DO 100 I=1,10
         ISUM = ISUM + I*I
100 CONTINUE
```

- FORTRAN introduced many high-level language constructs still in use today
  - Variables & assignment
  - Loops
  - Conditionals
  - Subroutines
  - Comments

ALGOL



Revised Report on the Algorithmic Language ALGOL 60

PETER NAUR (Editor)

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Dedicated to the Memory of William Turanski

SUMMARY

The report gives a complete defining description of the international algorithmic language ALGOL 60. This is a language suitable for expressing a large class of numerical processes in a form sufficiently concise for direct automatic translation into the language of programmed automatic computers.

The introduction contains an account of the preparatory work leading up to the final conference, where the language

CONTENTS

INTRODUCTION
1. STRUCTURE OF THE LANGUAGE
   1.1. Formalism for syntactic description
2. BASIC SYMBOLS, IDENTIFIERS, NUMBERS, AND STRINGS. BASIC CONCEPTS.
   2.1. Letters
   2.2. Digits. Logical values.
   2.3. Delimiters
   2.4. Identifiers

Communications of the ACM 1

- ALGOL = ALGOrithmic Language
- Developed by an international committee
- First version in 1958 (not widely used)
- Second version in 1960 (widely used)

- Sample code

```
comment Sum of squares
begin
  integer i, sum;
  for i:=1 until 10 do
     sum := sum + i*i;
end
```

- ALGOL 60 included *recursion*
  - Pro: easier to design clear, succinct algorithms
  - Con: too hard to implement; too inefficient

COBOL

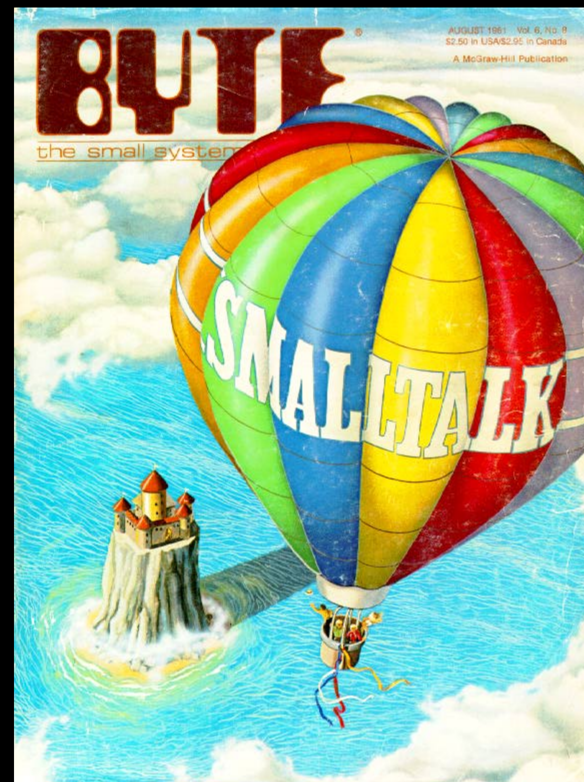
- COBOL = COmmon Business Oriented Language
- Developed by the US government (about 1960)
  - Design was greatly influenced by Grace Hopper
- Goal: Programs should look like English
  - Idea was that *anyone* should be able to read and understand a COBOL program

- COBOL included the idea of *records* (a single data structure with multiple *fields*, each field holding a value)

[Wikipedia]

Simula & Smalltalk

- These languages introduced and popularized *Object Oriented Programming* (OOP)
  - Simula was developed in Norway as a language for simulation in the 60s
  - Smalltalk was developed at Xerox PARC in the 70s
- These languages included
  - Classes
  - Objects
  - Subclasses & Inheritance



Java – 1995

- Java includes
  - Assignment statements, loops, conditionals from FORTRAN (but syntax from C)
  - Recursion from ALGOL
  - Fields from COBOL
  - OOP from Simula & Smalltalk

We assume you already know Java…

- Classes and objects
- Static vs instance fields and methods
- Local variables
- Primitive vs reference types
- Private vs public vs package
- Constructors
- Method signatures
- Arrays
- Subtypes and Inheritance, Shadowing

Java is object oriented

- In most prior languages, code was executed line by line and accessed variables or record
- In Java, we think of the data as being organized into objects that come with their own methods, which are used to access them
  - This shift in perspective is critical
  - When coding in Java one is always thinking about "which object is running this code?"

Dynamic vs. Static

- Some kinds of information is "static"
  - There can only be one instance
  - Like a "global variable" in C or C++ (or assembler)
  - In languages like FORTRAN, COBOL most data is static.
- Object-oriented information is "dynamic"
  - Each object has its own private copy
  - When we create a new object, we make new copies of the variables it uses to keep its state
  - Languages like C and C++ allow us to allocate memory at runtime, but don't offer a lot of help for managing it
- In Java this distinction becomes very important

Constructors

- Called to create new instances of a class
- Default constructor initializes all fields to default values (0 or `null`)

```
class Thing {
   int val;

   Thing(int val) {
      this.val = val;
   }

   Thing() {
      this(3);
   }
}
```

```
Thing one   = new Thing(1);
Thing two   = new Thing(2);
Thing three = new Thing();
```

Static Initializers

- Run once when class is loaded
- Used to initialize static objects

```
class StaticInit {

   static String[] courses = new String[2];

   static {
      courses[0]="CS 2110";
      courses[1]="CS 2112";
   }

   public static void main(String[] args) {
      ...
   }
}
```

Static methods and variables

- If a method or a variable is declared "static" there will be just one instance for the class
  - Otherwise, we think of each object as having its own "version" of the method or variable
- Anyone can call a static method or access a static variable
- But to access a dynamic method or variable Java needs to know which object you mean

Static vs Instance Example

```
class Widget {
   static int nextSerialNumber = 10000;
   int serialNumber;

   Widget() {
      serialNumber = nextSerialNumber;
      nextSerialNumber++;
   }

   public static void main(String[] args) {
      Widget a = new Widget();
      Widget b = new Widget();
      Widget c = new Widget();
      System.out.println(a.serialNumber);
      System.out.println(b.serialNumber);
      System.out.println(c.serialNumber);
   }}
```

Names

- Refer to my static and instance fields & methods of same class/object by (unqualified) name:
  - **`serialNumber`**
  - **`nextSerialNumber`**
- Refer to static fields & methods in another class using name of the class
  - **`Widget.nextSerialNumber`**
- Refer to instance fields & methods of another object using name of the object
  - **`a.serialNumber`**
- Example
  - **`System.out.println(a.serialNumber)`**
    - **`out`** is a static field in class **`System`**
    - The value of **`System.out`** is an instance of a class that has an instance method **`println(int)`**
- If an object must refer to itself, use **`this`**

A Common Pitfall

local variable shadows field

```
class Thing {
    int val;

    boolean setVal(int v) {
        int val = v;
    }
}
```

- you would like to set the instance field **`val = v`**
- but you have declared a new local variable **`val`**
- assignment has no effect on the field **`val`**

The `main` Method

Can be called from anywhere

A class method; don't need an object to call it

No return value

Method must be named **`main`**

```
public static void main(String[] args)
{
    . . .
}
```

Parameters passed to program, either from command line or from "Run"/"Debug" dialog box in Eclipse

Avoiding trouble

- Keep in mind that “main” is a static method
  - Hence anything main calls needs to have an associated object instance, or itself be static
- Use of static methods is discouraged

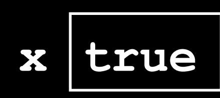
```
class Thing {
   int counter;
   static int sequence;

   public static void main(String[] args) {
      int c = ++counter; // Illegal: counter is assoc
                         // with an object of type
                         // Thing.  But which object?
      int s = ++sequence;// Legal: sequence is
                         // static too
   }
}
```

Overloading of Methods

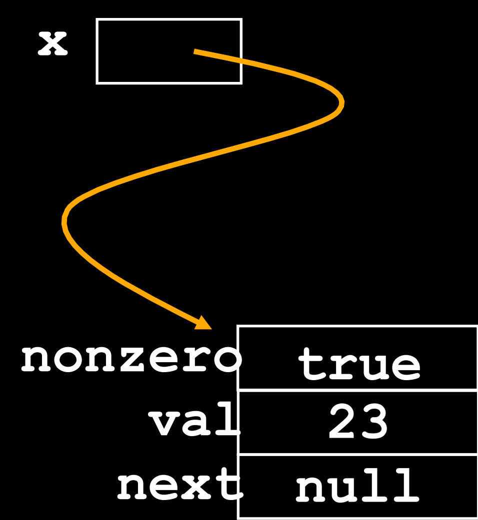
- A class can have several methods of the same name
  - But all methods must have different *signatures*
  - The *signature* of a method is its name plus types of its parameters
- Example: **`String.valueOf(...)`** in Java API
  - There are 9 of them:
    - **`valueOf(boolean);`**
    - **`valueOf(int);`**
    - **`valueOf(long);`**
    - **`...`**
- Parameter types are part of the method's signature

Primitive vs Reference Types

- Primitive types
  - **`int`, `short`, `long`, `float`, `byte`, `char`, `boolean`, `double`**
  - efficient
  - 1 or 2 words
  - not an **`Object`** — *unboxed*



- Reference types
  - objects and arrays
  - **`String`, `int[]`, `HashSet`**
  - usually require more memory
  - can have special value **`null`**
  - can compare **`null`** with **`==`, `!=`**
  - generate **`NullPointerException`** if you try to dereference **`null`**

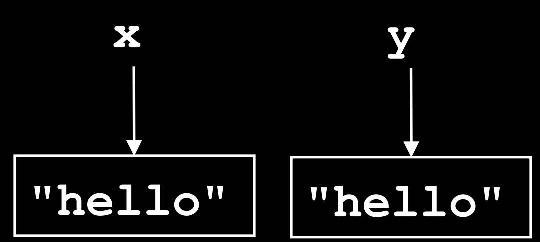


“==“ is not “equals( )”

- `==` tests whether variables hold identical values
  - shallow equality
  - works fine for primitive types
- `equals()` test whether two objects (e.g., `String`) contain equivalent data
  - deep equality
  - need to use for reference types

Two different strings with value `"hello"`

```
x = "hello";
y = "hello";
x == y
```



- To compare object *contents*, override `Object.equals()`
- But if you do this, must also override `Object.hashCode()` (more on this later)

“==“ vs “equals( )” for String

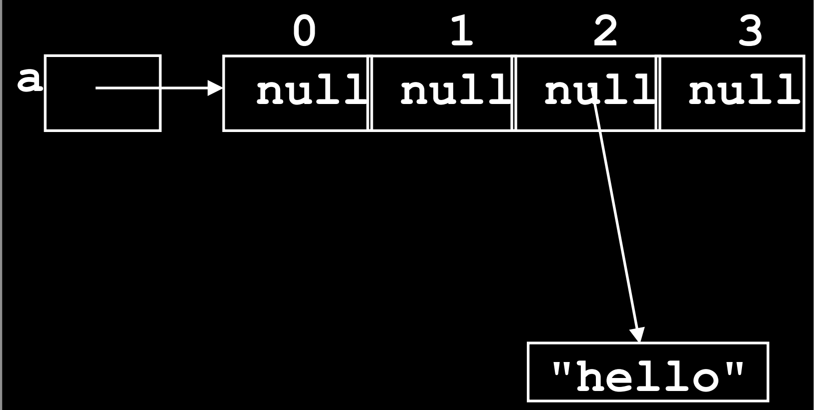
What you wrote.	Value?	What you should write.
"xy" == new String("xy")	False	"xy".equals(new String("xy"))
"xy" == "xy"	True	"xy".equals("xy")
"xy" == "x" + "y"	True	"xy".equals("x" + "y")

Use of “==“ quite tricky for Strings---see Equals.java

Arrays

- Arrays are reference types
- Array *elements* can be reference types or primitive types
  - E.g., `int[]` or `String[]`
- If `a` is an array, `a.length` is its length
- Its elements are `a[0]`, `a[1]`, ..., `a[a.length-1]`
- The length is fixed!

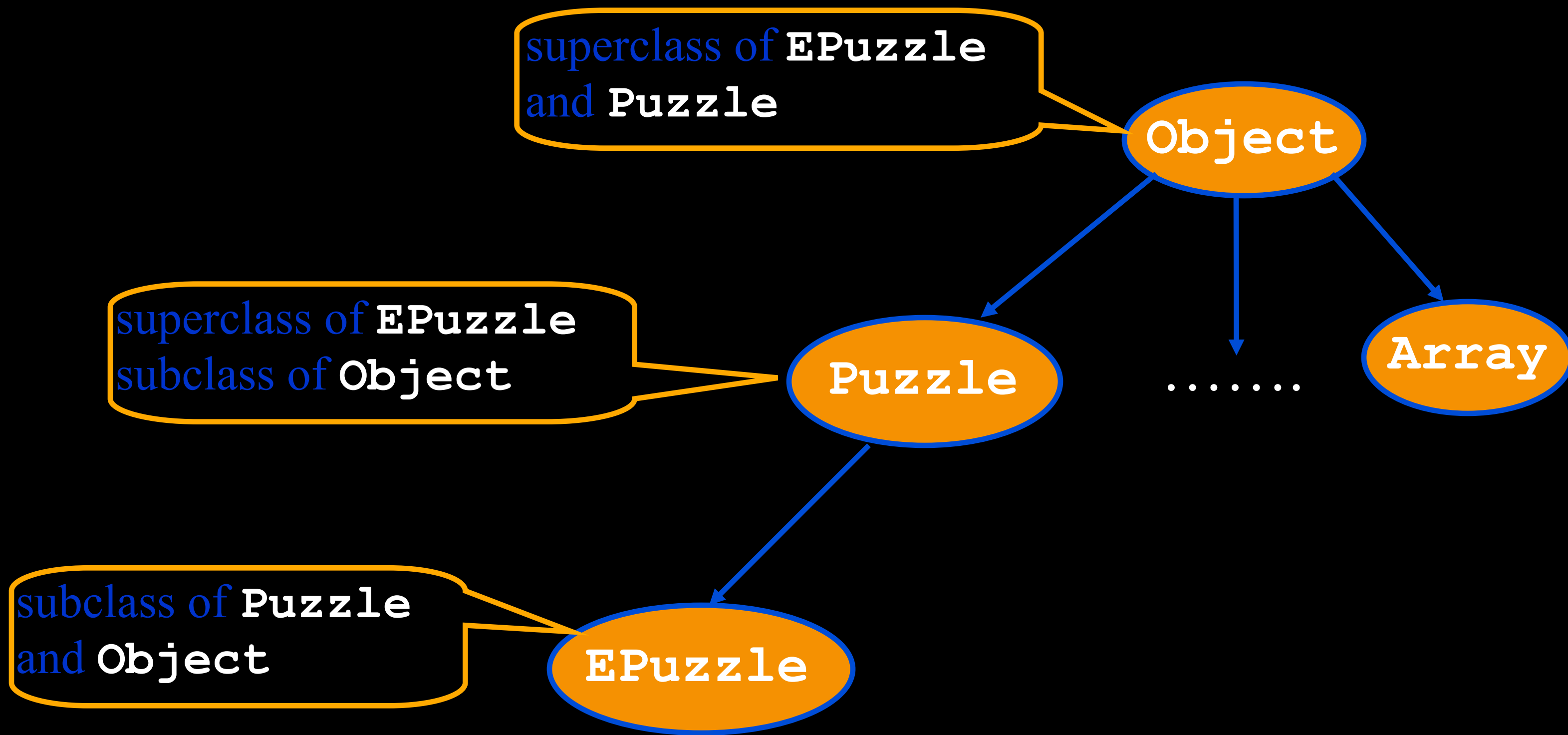
```
String[] a = new String[4];
a.length == 4;
a[2] = “hello”;
```



Accessing Array Elements Sequentially

```
public class CommandLineArgs {

   public static void main(String[] args) {

      System.out.println(args.length);

      // old-style
      for (int i = 0; i < args.length; i++) {
         System.out.println(args[i]);
      }

      // new style
      for (String s : args) {
         System.out.println(s);
      }
   }
}
```

Class Hierarchy



Every class (except `Object`) has a unique immediate superclass, called its *parent*

Overriding

- A method in a subclass overrides a method in superclass if:
  - both methods have the same name,
  - both methods have the same signature (number and type of parameters and return type), and
  - both are static methods or both are instance methods

- Methods are dispatched according to the runtime type of the object (dynamic binding / late binding)

Overriding (cont'd)

Casting and Method Dispatch

```
class A {
   public int m() {...}
}

class B extends A {
   public int m() {...}
}

B b = new B();
b.m();
A a = new B(); //upcasting
a.m();
```

Always calls methods of the class that was use for creation with "new".

Overriding (cont'd)

Unexpected Consequence

```
class A {
   public int m() {...}
}

class B extends A {
   private int m() {...} //illegal!
}

A a = new B(); //upcasting
a.m();
            //would invoke private method in
            // class B at runtime!
```

An overriding method cannot have more restricted access than the method it overrides

Accessing Overridden Methods

- Suppose a class `S` overrides a method `m` in its parent
- Methods in `S` can invoke the overridden method in the parent as

```
super.m()
```

- In particular, can invoke the overridden method in the overriding method!

- Caveat: cannot compose super more than once as in `super.super.m()`

Overloading Revisited

Remember: overloading resolved at compile time

```
class Base { … }
class Derived extends Base { … }
class Overload{
   public void m (Derived b){
      System.out.println("Overload.m(Derived)");
   }
   public void m (Base a){
      System.out.println("Overload.m(Base)");
   }
   public static void main(String []args){
      Overload t = new Overload ();
      Base     b = new Base();
      Base     d = new Derived();
      t.m(b);
      t.m(d);
   }
}
```

Output:

```
Overload.m(Base)
Overload.m(Base)
```

Shadowing

- Like overriding, but for fields instead of methods
  - Superclass: variable v of some type
  - Subclass: variable v perhaps of some other type
  - Method in subclass can access shadowed variable using super.v
- Variable references are resolved using static binding (i.e., at compile-time), not dynamic binding (i.e., not at runtime)
  - Variable reference r.v uses the static type (declared type) of the variable r, not the runtime type of the object referred to by r
- Shadowing variables is bad medicine and should be avoided

Experimentation and Debugging

- Don't be afraid to experiment if you are not sure how things work
  - Documentation isn't always clear
  - Interactive Development Environments (IDEs), e.g. Eclipse, make this easier
- Debugging
  - Do not just make random changes, hoping something will work
  - Think about what could cause the observed behavior
  - Isolate the bug
- An IDE makes this easier by providing a Debugging Mode
- Can set breakpoints, step through the program while watching chosen variables