

CS61B Lecture #10: OOP mechanism and Class Design

Comment. I notice that some of you use laptops in class. While I don't enforce any policy about this, I do think it problematic much of the time. Some people go so far as to read email, watch YouTube videos, or check Facebook in class (which is silly, since attendance is not required). Others try to make more legitimate use, such as taking notes. However, those who do take notes might want to check out this article.

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CS61B: Lecture #10 1

Review: A Puzzle

```
class A {
    void f() {
        System.out.println("A.f");
    }
    void g() { f(); /* or this.f() */ }
}

class B extends A {
    void f() {
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}

class C {
    static void main(String[] args) {
        B aB = new B();
        h(aB);
    }

    static void h(A x) { x.g(); }
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```

1. What is printed?
2. If we made `g` static?
3. If we made `f` static?
4. If we overrode `g` in `B`?
5. If `f` not defined in `A`?

Choices

- a. A.f
- b. B.f
- c. Some kind of error

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CS61B: Lecture #10 2

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CS61B: Lecture #10 3

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CS61B: Lecture #10 4

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CS61B: Lecture #10 5

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CS61B: Lecture #10 6

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CS61B: Lecture #10 7

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CS61B: Lecture #10 8

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CS61B: Lecture #10 9

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CS61B: Lecture #10 10

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Answer to Puzzle

1. Executing `java C` prints _____, because
 - A. `C.main` calls `h` and passes it `aB`, whose dynamic type is `B`.
 - B. `h` calls `x.g()`. Since `g` is inherited by `B`, we execute the code for `g` in class `A`.
 - C. `g` calls `this.f()`. Now `this` contains the value of `h`'s argument, whose dynamic type is `B`. Therefore, we execute the definition of `f` that is in `B`.
 - D. In calls to `f`, in other words, static type is ignored in figuring out what method to call.
2. If `g` were static, we see _____; selection of `f` still depends on dynamic type of `this`. Same for overriding `g` in `B`.
3. If `f` were static, would print _____ because then selection of `f` would depend on static type of `this`, which is `A`.
4. If `f` were not defined in `A`, we'd see _____

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Answer to Puzzle

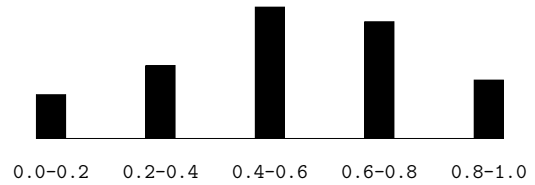
- Executing `java C` prints `B.f`, because
 - `C.main` calls `h` and passes it `aB`, whose dynamic type is `B`.
 - `h` calls `x.g()`. Since `g` is inherited by `B`, we execute the code for `g` in class `A`.
 - `g` calls `this.f()`. Now `this` contains the value of `h`'s argument, whose dynamic type is `B`. Therefore, we execute the definition of `f` that is in `B`.
 - In calls to `f`, in other words, static type is ignored in figuring out what method to call.
- If `g` were static, we see `B.f`; selection of `f` still depends on dynamic type of `this`. Same for overriding `g` in `B`.
- If `f` were static, would print `A.f` because then selection of `f` would depend on static type of `this`, which is `A`.
- If `f` were not defined in `A`, we'd see a compile-time error

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Example: Designing a Class

Problem: Want a class that represents histograms, like this one:



Analysis: What do we need from it? At least:

- Specify buckets and limits.
- Accumulate counts of values.
- Retrieve counts of values.
- Retrieve numbers of buckets and other initial parameters.

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Specification Seen by Clients

- The *clients* of a module (class, program, etc.) are the programs or methods that *use* that module's exported definitions.
- In Java, intention is that exported definitions are designated **public**.
- Clients are intended to rely on *specifications*, (aka APIs) not code.
- Syntactic specification:** method and constructor headers—syntax needed to use.
- Semantic specification:** what they do. No formal notation, so use comments.
 - Semantic specification is a *contract*.
 - Conditions client must satisfy (*preconditions*, marked "Pre:" in examples below).
 - Promised results (*postconditions*).
 - Design these to be *all the client needs!*
 - Exceptions communicate errors, specifically failure to meet preconditions.

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Histogram Specification and Use

```
/** A histogram of floating-point values */
public interface Histogram {
    /** The number of buckets in THIS. */
    int size();

    /** Lower bound of bucket #K. Pre: 0<=K<size(). */
    double low(int k);

    /** # of values in bucket #K. Pre: 0<=K<size(). */
    int count(int k);

    /** Add VAL to the histogram. */
    void add(double val);
}

void fillHistogram(Histogram H,
                  Scanner in) {
    while (in.hasNextDouble())
        H.add(in.nextDouble());
}
```

Sample output:

```
>= 0.00 | 10
>= 10.25 | 80
>= 20.50 | 120
>= 30.75 | 50
```

```
void printHistogram(Histogram H) {
    for (int i = 0; i < H.size(); i += 1)
        System.out.printf(
            ">=%5.2f | %4d\n",
            H.low(i), H.count(i));
}
```

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An Implementation

```
public class FixedHistogram implements Histogram {
    private double low, high; /* From constructor*/
    private int[] count; /* Value counts */

    /** A new histogram with SIZE buckets of values >= LOW and < HIGH. */
    public FixedHistogram(int size, double low, double high)
    {
        if (low >= high || size <= 0) throw new IllegalArgumentException();
        this.low = low; this.high = high;
        this.count = new int[size];
    }

    public int size() { return count.length; }
    public double low(int k) { return low + k * (high-low)/count.length; }

    public int count(int k) { return count[k]; }

    public void add(double val) {
        if (val >= low && val < high)
            count[(int) ((val-low)/(high-low) * count.length)] += 1;
    }
}
```

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Let's Make a Tiny Change

Don't require a priori bounds:

```
class FlexHistogram implements Histogram {
    /** A new histogram with SIZE buckets. */
    public FlexHistogram(int size) {
        ?
    }
    // What needs to change?
}
```

- How would you do this? Profoundly changes implementation.
- But *clients* (like `printHistogram` and `fillHistogram`) still work with no changes.
- Illustrates the power of *separation of concerns*.

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Implementing the Tiny Change

- Pointless to pre-allocate the `count` array.
- Don't know bounds, so must save arguments to `add`.
- Then recompute `count` array "lazily" when `count(...)` called.
- Invalidate `count` array whenever histogram changes.

```
class FlexHistogram implements Histogram {
    private ArrayList<Double> values = new ArrayList<>();
    int size;
    private int[] count;

    public FlexHistogram(int size) { this.size = size; this.count = null;
    }

    public void add(double x) { count = null; values.add(x); }

    public int count(int k) {
        if (count == null) { compute count from values here. }
        return count[k];
    }
}
```

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Advantages of Procedural Interface over Visible Fields

By using public method for `count` instead of making the array `count` visible, the "tiny change" is transparent to clients:

- If client had to write `myHist.count[k]`, it would mean
"The number of items currently in the k^{th} bucket of histogram `myHist` (which, by the way, is stored in an array called `count` in `myHist` that always holds the up-to-date count)."
• Parenthetical comment *worse than useless* to the client.
- If `count` array had been visible, after "tiny change," every use of `count` in client program would have to change.
- So using a method for the public `count` method decreases what client *has to* know, and (therefore) has to change.

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