# CS61B Lecture #10: OOP Mechanisms and Class Design

# Review: A Puzzle

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

```
class B extends A {
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}
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```
class C {
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3. If we made `f` static?
4. If we overrode `g` in `B`?
5. If `f` not defined in A?

**Choices**

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b. `B.f`
c. Some kind of error

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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`.

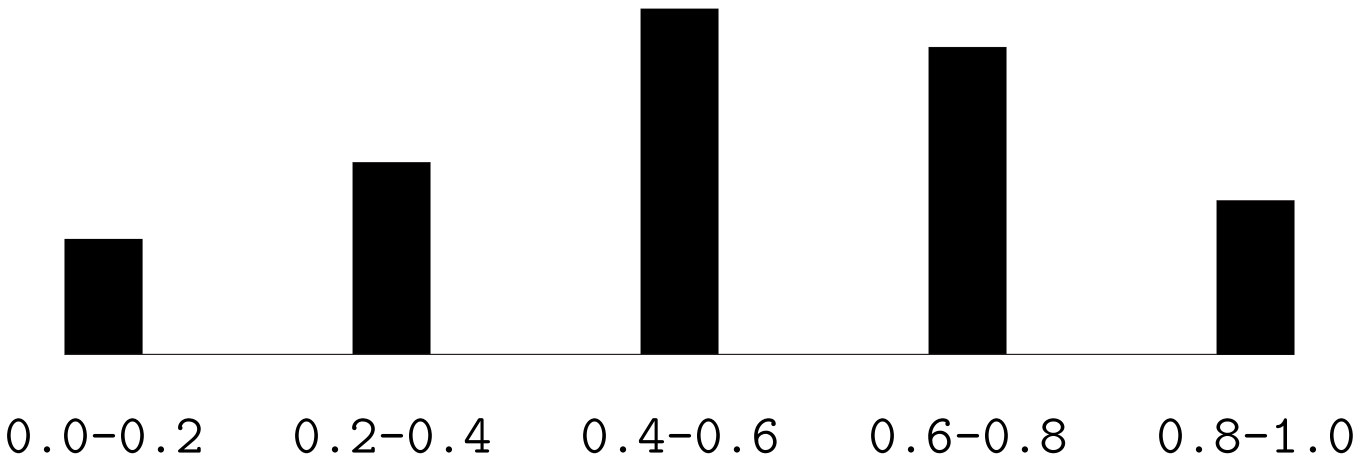
4. If `f` were not defined in `A`, we'd see ______

# Answer to Puzzle

1. Executing `java C` prints <u>B.f</u>, 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 <u>B.f</u>; selection of `f` still depends on dynamic type of `this`. Same for overriding `g` in `B`.
3. If `f` were static, would print <u>A.f</u> 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 <u>a compile-time error</u>

# 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.

# 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 pre-conditions.

# 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);
}
```

*Sample output:*

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

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

```
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));
}
```

# 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();
    _low = low; _high = high;
    _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;
  }
}
```

# 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*.

# 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) { _size = size; _count = null;  }

   public int size() { return _size; }

   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];
   }
}
```

# 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 $k^{\text{th}}$ 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.