ture #9: Interfaces and Abstract Classes

Recreation

ny polynomial with a leading coefficient of 1 and integral
rational roots are integers.

ts are individual efforts in this class (no partnerships).
cuss projects or pieces of them before doing the work.
omplete each project yourself. That is, feel free to
s with each other, but be aware that we expect your
tantially different from that of all your classmates (in
r semester). You will find a more detailed account of
ler the "Course Info" tab on the course website.

Abstract Methods and Classes

thod can be *abstract:* No body given; must be supplied

e is in specifying a pure interface to a family of types:

```
ble object. */
ract class Drawable {
tract class" = "can't say new Drawable"
and THIS by a factor of XSIZE in the X direction,
 YSIZE in the Y direction. */
abstract void scale(double xsize, double ysize);

w THIS on the standard output. */
abstract void draw();
```

ble is something that has *at least* the operations scale
it.

a Drawable because it's abstract.

his case, it wouldn't make any sense to create one, be-
two methods without any implementation.

Methods on Drawables

```
drawable object. */
 abstract class Drawable {
* Expand THIS by a factor of SIZE */
blic abstract void scale(double xsize, double ysize);
* Draw THIS on the standard output. */
blic abstract void draw();
```

ew Drawable(), *BUT*, we can write methods that operate
s in Drawable or in other classes:

```
l(Drawable[] thingsToDraw) {
wable thing : thingsToDraw)
g.draw();
```

no implementation! How can this work?

Concrete Subclasses

ses can extend abstract ones to make them "less ab-
verriding their abstract methods.

nds of Drawables that are *concrete*, in that all methods
entations and one can use **new** on them:

Concrete Subclass Examples

```
tangle extends Drawable {
ngle(double w, double h) { this.w = w; this.h = h; }
scale(double xsize, double ysize) {
ze; h *= ysize;

draw() { draw a w x h rectangle }
le w,h;
```

Oval or Rectangle is a Drawable.

```
l extends Drawable {
double xrad, double yrad) {
d = xrad; this.yrad = yrad;

scale(double xsize, double ysize) {
xsize; yrad *= ysize;

draw() { draw an oval with axes xrad and yrad }
le xrad, yrad;
```


Using Concrete Classes

te new Rectangles and Ovals.

classes are subtypes of Drawable, we can put them in
r whose static type is Drawable, ...

fore can pass them to any method that expects Drawable

```
e[] things = {
 Rectangle(3, 4), new Oval(2, 2)

(things);
```

l rectangle and a circle with radius 2.

Interfaces

nglish usage, an *interface* is a "point where interaction een two systems, processes, subjects, etc." (*Concise ionary*).

ing, often use the term to mean a *description* of this raction, specifically, a description of the functions or which two things interact.

e term to refer to a slight variant of an abstract class ava 1.7) contains only abstract methods (and static con- this:

```
ace Drawable {
double xsize, double ysize);   // Automatically public.
;
```

re automatically abstract: can't say `new Drawable();` `Rectangle(...)`.

Aside: Documentation

ecker would insist on comments for all the methods, , and fields of the concrete subtypes.

dy have comments for `draw` and `scale` in the class `Drawable`, e idea of object-oriented programming is that the sub- m to the supertype both in syntax and behavior (all ds scale their figure), so comments are generally not erriding methods. Still, the reader would like to know method *does* override something.

`Override` annotation. We can write:

```
de
void scale(double xsize, double ysize) {
d *= xsize; yrad *= ysize;

de
void draw() { draw a circle with radius rad }
```

will check that these method headers are proper over- e parent's methods, and our style checker won't com- he lack of comments.

Multiple Inheritance

one class, but *implement* any number of interfaces.

ample:

```
dable {
);


table {
ject x);


implements Readable {
ct get() { ... }
```

```
void copy(Readable r,
          Writable w) {
  w.put(r.get());
}


class Sink implements Writable {
  public void put(Object x) { ... }
}
```

```
class Variable implements Readable, Writable {
  public Object get() { ... }
  public void put(Object x) { ... }
}
```

gument of `copy` can be a `Source` or a `Variable`. The e a `Sink` or a `Variable`.

Implementing Interfaces

eat Java interfaces as the public specifications of data asses as their implementations:

```
class Rectangle implements Drawable { ... }
```

ordinary classes and *implement* interfaces, hence the yword.)

nterface as for abstract classes:

```
awAll(Drawable[] thingsToDraw) {
 (Drawable thing : thingsToDraw)
 thing.draw();
```

orks for `Rectangles` and any other implementation of

Map in Java

```
n one integer argument */

 IntUnaryFunction {
x);
```

```
IntList map(IntUnaryFunction proc,
            IntList items) {
  if (items == null)
    return null;
  else return new IntList(
      proc.apply(items.head),
      map(proc, items.tail)
    );
}
```

of this function that's clumsy. First, define class for e function; then create an instance:

```
mplements IntUnaryFunction {
t apply(int x) { return Math.abs(x); }

-----------------------------------
 Abs(), some list);
```


Review: Higher-Order Functions

u had *higher-order functions* like this:

```
c,      items):
ion      list
 is None:
rn None

rn IntList(proc(items.head), map(proc, items.tail))
```

d write

```
, makeList(-10, 2, -11, 17))
 makeList(10, 2, 11, 17)
bda x: x * x, makeList(1, 2, 3, 4))
 makeList(t(1, 4, 9, 16)
```

t have these directly, but can use abstract classes or nd subtyping to get the same effect (with more writing)

Lambda Expressions

e can create classes likes `Abs` on the fly with *anonymous*

```
 IntUnaryFunction() {
public int apply(int x) { return Math.abs(x); }
some list);
```

of like declaring

```
Anonymous implements IntUnaryFunction {
lic int apply(int x) { return Math.abs(x); }
```

ting

```
(new Anonymous(), some list);
```


Lambda in Java 8

mbda expressions are even more succinct:

```
t x) -> Math.abs(x), some list);
better, when the function already exists:
h::abs, some list);
```

out you need an anonymous `IntUnaryFunction` and cre-

examples in `galaxy.GUI`:

```
Button("Game->New", this::newGame);
```

cond parameter of `ucb.gui2.TopLevel.addMenuButton` *function.*

ava library type `java.util.function.Consumer`, which gument method, like `IntUnaryFunction`,

eriting Headers vs. Method Bodies

lement multiple interfaces, but extend only one class: *rface inheritance*, but *single body inheritance*.

is simple, and pretty easy for language implementors to

ere are cases where it would be nice to be able to "mix tations from a number of sources.

g Supertypes, Default Implementations

above, before Java 8, interfaces contained just static d abstract methods.

duced static methods into interfaces and also *default* ich are essentially instance methods and are used when- d of a class implementing the interface would otherwise

nt to add a new one-parameter `scale` method to all con- sses of the interface `Drawable`. Normally, that would g an implementation of that method to all concrete

tead make `Drawable` an abstract class again, but in the that can have its own problems.

Default Methods in Interfaces

troduced default methods:

```
rface Drawable {
e(double xsize, double ysize);
();

 by SIZE in the X and Y dimensions. */
oid scale(double size) {
(size, size);
```

re, but, as in other languages with full multiple inher- C++ and Python), it can lead to confusing programs. I use them sparingly.