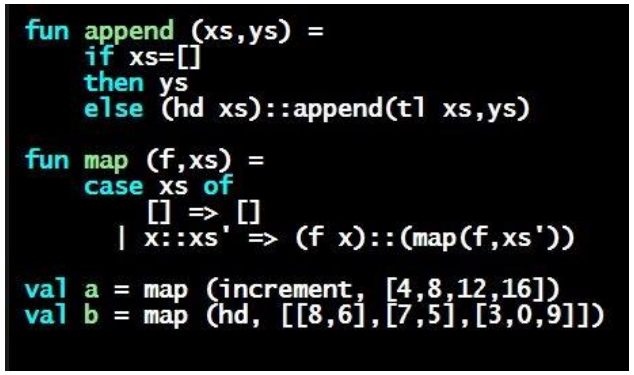

Programming Languages

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Subtyping for OOP

Now…

Use what we learned about subtyping for records and functions to understand subtyping for class-based OOP

- Like in Java/C#

Recall:

- Class names are also types
- Subclasses are also subtypes
- Substitution principle: Instance of subclass should usable in place of instance of superclass

An object is…

- Objects: mostly records holding fields and methods
  - Fields are mutable
  - Methods are immutable functions that also have access to **`self`**

- So *could* design a type system using types very much like record types
  - Subtypes could have extra fields and methods
  - Overriding methods could have contravariant arguments and covariant results compared to method overridden
    - Sound only because method “slots” are immutable!

Actual Java/C#…

Compare/contrast to what our "theory" allows:

1. Types are class names and subtyping are explicit subclasses
2. A subclass can add fields and methods
3. A subclass can override a method with a covariant return type
   - (No contravariant arguments; instead makes it a non-overriding method of the same name)

(1) Is a subset of what is sound (so also sound)

(3) Is a subset of what is sound and a different choice (adding method instead of overriding)

Classes vs. Types

- A class defines an object's behavior
  - Subclassing inherits behavior and changes it via extension and overriding

- A type describes an object's methods' argument/result types
  - A subtype is substitutable in terms of its field/method types

- These are separate concepts: try to use the terms correctly
  - Java/C# confuse them by requiring subclasses to be subtypes
  - A class name is both a class and a type
  - This confusion is convenient in practice

Optional: More details

Java and C# are sound: They do not allow subtypes to do things that would lead to “method missing” or accessing a field at the wrong type

Confusing (?) Java example:

- Subclass can declare field name already declared by superclass
- Two classes can use any two types for the field name
- Instance of subclass have two fields with same name
- “Which field is in scope” depends on which class defined the method

Optional: `self/this` *is special*

- Recall our Racket encoding of OOP-style
  - "Objects" have a list of fields and a list of functions that take `self` as an explicit extra argument

- So if `self/this` is a function argument, is it contravariant?
  - No, it is *covariant*: a method in a subclass can use fields and methods only available in the subclass: essential for OOP

```
class A {
  int m(){ return 0; }
}
class B extends A {
  int x;
  int m(){ return x; }
}
```

  - Sound because calls always use the "whole object" for `self`
  - This is why coding up your own objects manually works much less well in a statically typed languages