The plan…

Several related topics:
• “Duck typing” – dynamic typing in Ruby
• Inheritance and classes
• Modularity and mixins

Next:
• Multiple inheritance, interfaces, and mixins

Then:
• Start on grammars, scanners, parsers
Types in Ruby

• Ruby is dynamically typed – everything is an object
• Only notion of an object’s “type” is what messages it can respond to
  – i.e., whether it has methods for a particular message
  – This can change dynamically for either all objects of a class or for individual objects
Duck Typing

• “If it walks like a duck and talks like a duck, it must be a duck”
  - Even if it isn’t
  - All that matters is how an object behaves
    • (i.e, what messages it understands)
Thought Experiment (1)

- What must be true about x for this method to work?

```python
def foo x
    x.m + x.n
end
```
Thought Experiment (2)

• What is true about x?
  
  \[ x.m + x.n \]

• Less than you might think
  
  – x must have 0-argument methods m and n
  
  – The object returned by x.m must have a + method that takes one argument
  
  – The object returned by x.n must have whatever methods are needed by x.m.+ (!)
Duck Typing Tradeoffs

• Plus
  – Convenient, promotes code reuse
  – All that matters is what messages an object can receive

• Minus
  – “Obvious” equivalences don’t hold: x+x, 2*x, x*2
  – May expose more about an object than might be desirable (more coupling in code)
  – May allow objects to “work” in unintended / inappropriate contexts
Classes & Inheritance

• Ruby vs Java:
  – Subclassing in Ruby is not about type checking (because of dynamic typing)
  – Subclassing in Ruby is about inheriting methods
• Can use `super` to refer to inherited code
• See examples in `points.rb`
  – `ThreeDPoint` inherits methods `x` and `y`
  – `ColorPoint` inherits `distance` methods
Overriding

• With dynamic typing, inheritance alone is just avoiding cut/paste
• Overriding is the key difference
  – When a method in a superclass makes a self call, it resolves to a method defined in the subclass if there is one
  – Example: distFromOrigin2 in PolarPoint
Ruby – Why Subclasses?

• Since we can add/change methods on the fly, why use a subclass?
• Instead of class `ColorPoint`, why not just add a color field to `Point`?
  – Can’t do this in Java
  – Can do it in Ruby, but it changes all `Point` instances (including subclasses), even existing ones
  – Pro: now all `Point` classes have a color
  – Con: Maybe that breaks something else or is the wrong abstraction for some `Point` clients
Organizing Large(r) Programs

• Issues
  – Idea: divide code into manageable components
  – Also: want to take advantage of reusable chunks of code (libraries, classes, etc.)

• Strategy: Split code into separate files
  – Typically, one or more classes per file
  – Use “require” (or sometimes “load”) to access in Ruby
  – What about components that aren’t classes?
Namespaces & Modules

• Idea: Want to break larger programs into pieces where names can be reused independently
  – Avoids clashes when combining libraries written by different organizations or at different times
• Ruby solution: modules
  – Separate source files that define name spaces, but not necessarily classes
module Trig
  PI = 3.14
  def Trig.sin(x)
    # …
  end
  def Trig.cos(x)
    # …
  end
end

module Moral
  VERY_BAD = 0
  BAD = 1
  def Moral.sin(badness)
    # …
  end
end
Using Modules

# …
require ‘trig’
require ‘moral’
y = Trig.sin(Trig::PI/4)
penance = Moral.sin(
    Moral::VERY_BAD)
# …

- Key point: Each module defines a namespace
  - No clashes with same names in other modules
- Module methods are a lot like class methods
Mixins

- Modules can be used to add behavior to classes – *mixins*
  - Define instance methods and data in module
  - “include” the module in a class – incorporates the module definitions into the class
    - Now the class has its original behavior plus whatever was added in the mixin
  - Provides most of the capabilities of multiple inheritance and/or Java interfaces
Example

module Debug
  def trace
    # …
  end
end

class Something
  include debug
  # …
end

class SomethingElse
  include debug
  # …
end

• Both classes have the trace method defined, and it can interact with other methods and data in the host class as if it was defined there
  – (trace is not “shared” by the classes and can’t pass information back and forth)
Exploiting Mixins – Comparable

• The real power of this is when mixins build on or interact with code in the classes that use them

• Example: library mixin Comparable
  – Class must define operator <=>
    (a <=> b returns -1, 0, +1 if a<b, a==b, a>b)
  – Comparable mixin uses “client” <=> to define <, <=, ==, =>, >, and between? for that class
Another example – Enumerable

• Container/collection class provides an each method to call a block for each item in the collection
• Enumerable module builds many mapping-like operations on top of this
  – map, include?, find_all, …
  – If items in the collection implement <=> you also get sort, min, max, …
Iterator Example

• Suppose we want to define a class of Sequence objects that have a from, to, and step, and contain numbers \( x \) such that
  - \( \text{from} \leq x \leq \text{to} \), and
  - \( x = \text{from} + n*\text{step} \) for integer value \( n \)

(Credit: *Ruby Programming Language*, Flanagan & Matsumoto)
Sequence Class & Constructor

class Sequence
  # mixin all of the methods in Enumerable
  include Enumerable

  def initialize(from, to, step)
    @from, @to, @step = from, to, step
  end

  ...

Sequence each method

• To add an iterator to Sequence and make it also work with Enumerable, all we need is this:

```ruby
def each
  x = @from
  while x <= @to
    yield x
    x += @step
  end
end
```