CMSC 330
Organization of Programming Languages

Code Blocks
Code Blocks

- A code block is a piece of code that is invoked by another piece of code

- Code blocks are useful for encapsulating repetitive computations
Array Iteration with Code Blocks

• The Array class has an each method
  • Takes a code block as an argument

```
a = [1,2,3,4,5]
a.each { |x| puts x }
```
Array Iteration with Code Blocks

- The **Array** class has an **each** method
  - Takes a code block as an argument

```ruby
a = [1,2,3,4,5]
a.each do |x| puts x end
```

or delimited by `do ... end`
So, What Are Code Blocks?

- A code block is like a special kind of method

  ```ruby
  { |y| x = y + 1; puts x }
  ```

  is almost the same as

  ```ruby
  def m(y) x = y + 1; puts x end
  ```

- The **each** method invokes the given code block
  - This is called **higher-order programming**
    - In other words, methods take other (almost-)methods as arguments
Quiz 1: What is the output?

```ruby
a = [1,2,3,4]
sum = 0
a.each { |x| sum += 2*x }
puts sum
```

A. 10  
B. 30  
C. 20  
D. 0
Quiz 1: What is the output?

```ruby
a = [1,2,3,4]
sum = 0
a.each { |x| sum += 2*x }
puts sum
```

A. 10  
B. 30  
C. 20  
D. 0
More Code Blocks for Arrays

• Code block in `each` does not modify array

```ruby
a = [1,2]
a.each { |x| x = x*x }
puts a[1]
# outputs 2, not 4
```

• `a.find` returns first element of `a` for which the block returns true

```ruby
[1,2,3,4,5].find { |y| y % 2 == 0 }
[5,4,3].collect { |x| -x }
```

• `a.collect` applies block to each element of `a` and returns new array; `collect!` modifies `a`
Quiz 2: What is the output

```ruby
a = [20, 15, 10, 5]
a.collect! { |x| x*x }
puts a[1]
```

A. 10
B. 15
C. 225
D. 400
Quiz 2: What is the output

```ruby
a = [20,15,10,5]
a.collect! { |x| x*x }
puts a[1]
```

A. 10
B. 15
C. 225
D. 400
Code Blocks for Numbers, Strings

- n.times runs code block n times
- n.upto(m) runs code block for integers n..m

```ruby
3.times { puts "hello"; puts "goodbye" }
5.upto(10) { |x| puts(x + 1) }
```

- s.split(x) splits the string according to delimiter x, invoking the code block on each segment

```ruby
s = "Student,Sally,099112233,A"
s.split(\',\').each { |x| puts x }
```

("delimiter" = symbol used to denote boundaries)
Code Blocks for Files

- open method takes code block with file argument
  - File automatically closed after block executed
- readlines reads all lines from a file and returns an array of
  the lines read
  - Use each to iterate
- Can do something similar on strings directly:
  - "r1\nr2\n\nr4".each_line { |rec| puts rec }
  - Apply code block to each newline-separated substring

File.open("test.txt", "r") do |f|
  f.readlines.each { |line| puts line }
end

recall alternative syntax: do ... end instead of { ... }
Standard Library: File

- Lots of convenient methods for IO
  - `File.new("file.txt", "rw")`  # open for rw access
  - `f.readline`  # reads the next line from a file
  - `f.readlines`  # returns an array of all file lines
  - `f.eof`  # return true if at end of file
  - `f.close`  # close file
  - `f << object`  # convert object to string and write to f
  - `$stdin, $stdout, $stderr`  # global variables for standard UNIX IO
    By default, `$stdin` reads from keyboard, and `$stdout` and `$stderr` both write to terminal

- `File` inherits some of these methods from `IO`
Code Blocks for Hashes

• Can iterate over keys and values separately

```ruby
p = {}
p[“USA”] = 319
p[“Italy”] = 60
p.each { |k,v|
    puts “pop. of #{k} is #{v} million”
}
```

- pop. of USA is 319 million
- pop. of Italy is 60 million
Using Yield to Call Code Blocks

- Any method call can include a code block
  - Inside the method, the block is called with `yield`
- After the code block completes
  - Control returns to the caller after the yield instruction

```ruby
def twocalls
  return "No block" unless block_given?
  yield
  yield
end
```
```
No block
foo
foo
```
Yield Can Take an Argument

```ruby
def countx(x)
    for i in (1..x)
        puts "foo"
        yield i
    end
end

countx(4) { |x| puts x }
```

- **yield** can take any number of arguments
  - Code block `{ |x,y| ... }` invoked via `yield arg1,arg2`
  - Code block `{ |x,y,z| ... }` would be invoked via `yield arg1,arg2,arg3`
  - Etc.
Quiz 3: What is the output

def myFun(x)
    yield x
end
myFun(3) { |v| puts "#{v} #{v*v}" }

A. 3
B. 3 9
C. 9 81
D. 9 nil
Quiz 3: What is the output

```ruby
def myFun(x)
    yield x
end
myFun(3) { |v| puts "#{v} #{v*v}" }
```

A. 3
B. 3 9
C. 9 81
D. 9 nil
Code Blocks are not Objects

- Code blocks are limited in their use
  - They cannot be stored in variables, or passed to or returned from methods

```ruby
a = [1,2,3]
a.collect! { |z| z+1 }  # ok
y = { |z| z+1 }        # syntax error
a.collect! y          # syntax error
```

- Only code block literals are permitted, and can only be passed as the last “argument”
  - And only one code block, not more
Procs: First-class “code blocks”

- **Proc** can make an object out of a code block
  - \( t = \text{Proc.new} \{|x| \ x+2\} \)
- **Proc** objects can be passed around, stored, and have their code invoked via `call`

```ruby
def say(p)
    p.call 10
end

puts say(t)  # 12
```
Procs are a Little Clumsy

• Stringing them together is a little (syntactically) heavyweight
  • We will see with OCaml a better integration into the language

```ruby
def say(y)
  t = Proc.new { |x| Proc.new { |z| z + x + y } }
  return t
end
s = say(2).call(3)
puts s.call(4)
```

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Procs vs. code blocks

<table>
<thead>
<tr>
<th>Code block</th>
<th>Proc</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Lightweight syntax</td>
<td>• Heavier-weight syntax:</td>
</tr>
<tr>
<td>• Common in libraries, programming idioms</td>
<td>Must make a Proc from code block first</td>
</tr>
<tr>
<td>• “Second class” status</td>
<td>• Not commonly used in standard libraries</td>
</tr>
<tr>
<td>• Can only be last, implicit function argument, as a literal</td>
<td>• “First class” status</td>
</tr>
<tr>
<td>• Can invoke only from within called method</td>
<td>• Can pass as argument (or more than one), return as result, store in fields, etc.</td>
</tr>
<tr>
<td>□ Can’t make one and call it in the same method</td>
<td>• Call anywhere, directly</td>
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</tbody>
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Exceptions

• Use `begin...rescue...ensure...end`
  • Like `try...catch...finally` in Java

```ruby
begin
  f = File.open("test.txt", "r")
  while !f.eof
    line = f.readline
    puts line
  end
rescue Exception => e
  puts "Exception:" + e.to_s + " (class " + e.class.to_s + ")"
ensure
  f.close if f != nil
end
```

- Class of exception to catch
- Local name for exception
- Always happens
Command Line Arguments

- Stored in predefined global constant ARGV

- Example
  - If
    - Invoke test.rb as “ruby test.rb a b c”
  - Then
    - ARGV[0] = “a”
    - ARGV[1] = “b”
    - ARGV[2] = “c”