CMPU 101 §02 · Computer Science I

Evaluating Functions and Conditionals

7 September 2022

Assignment 1 due 11:59pm on Wednesday

Assignment 2 comes out on Thursday

Where are we?

We've been using Pyret to write expressions that use:

Data, including

numbers (`0`, `-10`, `0.4`),

strings (`""`, `"hi"`, `"111"`), and

images (`circle(2, "solid", "red")`).

Which we modify or combine using operators or functions like **`+`**, **`string-append`**, and **`above`**.

Distinguishing types of data helps to catch mistakes.

If you try to give

a string to `/` or

a number to **`overlay`**,

we want Pyret to catch the problem right early,
giving a helpful error message.

We've seen that we can create more complicated programs by composing function calls, e.g.,

```
1 + (2 / 3)
```

or

```
string-append("hello ",
  string-append("Pyret ", "world!"))
```

And we can give a name to the result of an expression, e.g.,

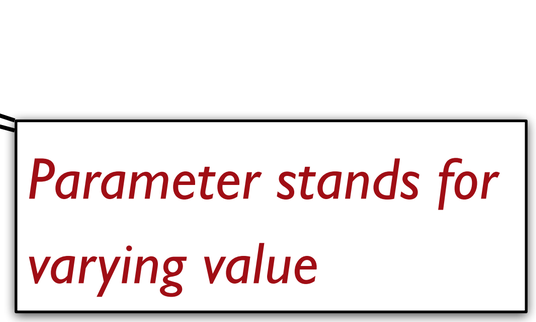
```
total = 2 + 3
```

Defining functions

Remember functions from middle-school math:

Given $f(x) = \cos(x) + 2$

$f(0) = 1 + 2 = 3$



Pyret functions work the same way:

```
fun f(x): num-cos(x) + 2 end

f(0)
→ num-cos(0) + 2
→ 1 + 2
→ 3
```

Function definitions in Pyret have this form:

```
fun ⟨function-name⟩ (⟨arg-name⟩, ...):
  ⟨expression⟩
end
```

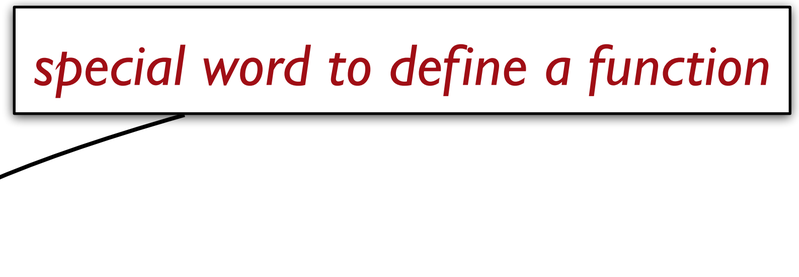
Example

Mary Berry needs to know how many cakes to bake for her cake shop.

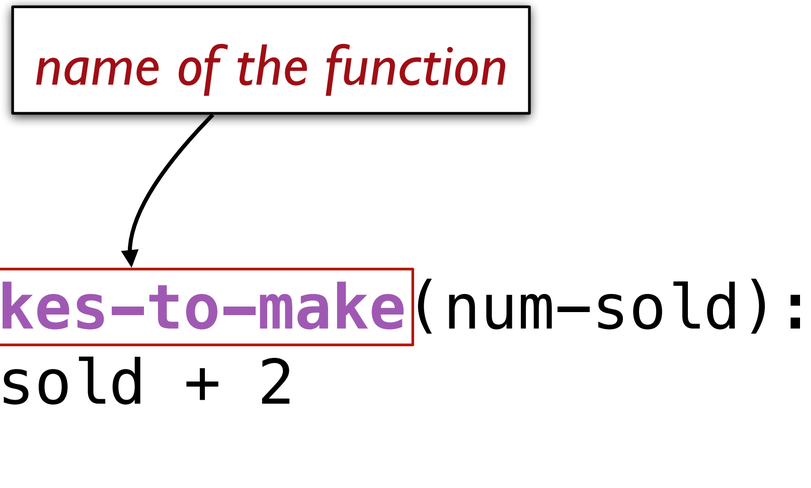
To avoid running out or having too many, she likes to bake two cakes more than the number she sold the previous day.

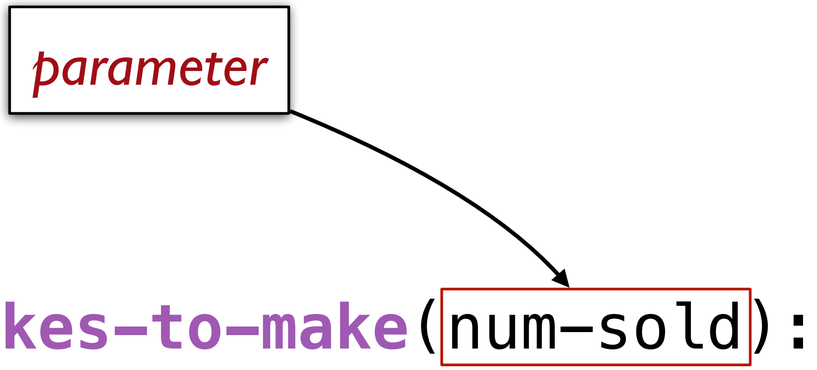
E.g., if Mary sells eight cakes on Monday, she makes ten cakes on Tuesday.

Let’s write some code to help Mary.



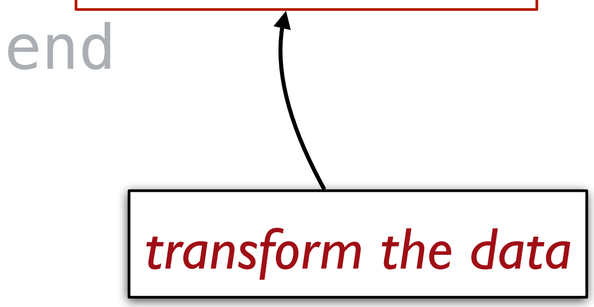

```
fun cakes-to-make(num-sold):
  num-sold + 2
end
```


name of the function
fun cakes-to-make(num-sold):
num-sold + 2
end

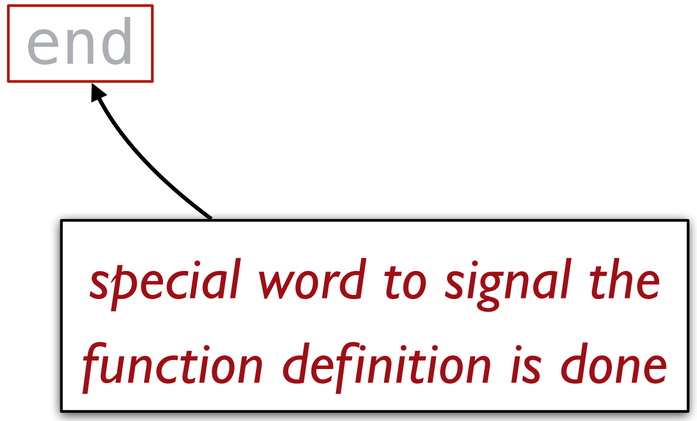



```
fun cakes-to-make(num-sold):
  num-sold + 2
end
```

```
fun cakes-to-make(num-sold):
  num-sold + 2
end
```



```
fun cakes-to-make(num-sold):
  num-sold + 2
end
```

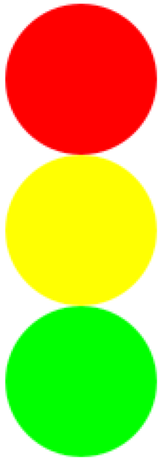


Functional abstraction

```
# Draw a traffic light
above(  circle(40, "solid", "red"),
  above(circle(40, "solid", "yellow"),
        circle(40, "solid", "green"))
```

Unchanging

Varying



```
# Draw a traffic light
above(circle(40, "solid", "red"),
  above(circle(40, "solid", "yellow"),
    circle(40, "solid", "green")))

# Can be changed to
fun bulb(color):
  circle(40, "solid", color)
end

above(bulb("red"),
  above(bulb("yellow"),
    bulb("green")))
```

```
fun bulb(color):
  circle(40, "solid", color)
end

fun traffic-light():
  above(bulb("red"),
    above(bulb("yellow"),
      bulb("green")))
end
```

Example

For Mary's cake shop, we want to determine the price of each cake based on the cost of the ingredients and the time to prepare it.

The price is twice the cost of the ingredients plus 1/4 of the preparation time in minutes.

Chocolate cake
Ingredients: $10
Preparation time: 20 minutes

```
choc-cake-price = (2 * 10) + (0.25 * 20)
```

Cheesecake
Ingredients: $15
Preparation time: 36 minutes

```
cheesecake-price = (2 * 15) + (0.25 * 36)
```

We use functions to avoid repetitive code when we need to perform the same operations on different values.

```
choc-cake-price = (2 * 10) + (0.25 * 20)
```

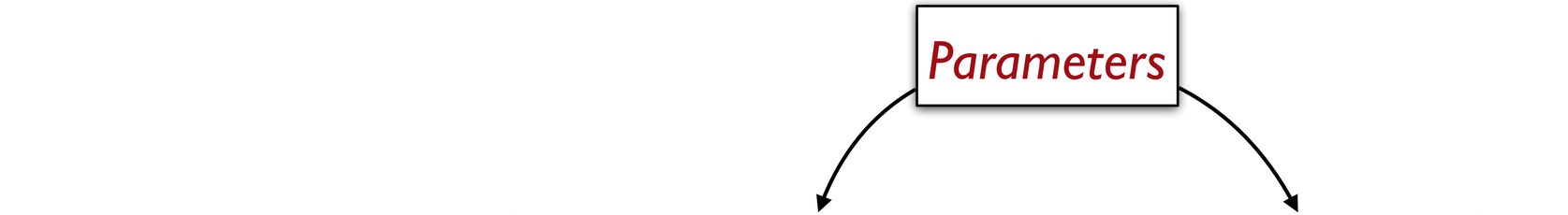
```
cheesecake-price = (2 * 15) + (0.25 * 36)
```

```
(2 * ingredients-cost) + (0.25 * prep-time)
```

We use functions to avoid repetitive code when we need to perform the same operations on different values.

```
choc-cake-price = (2 * 10) + (0.25 * 20)
```

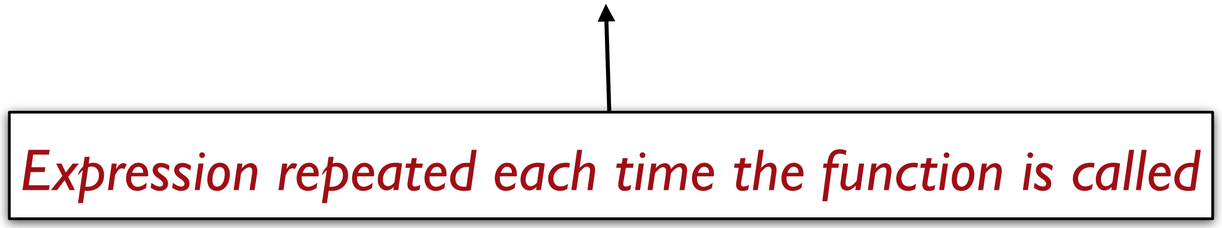
```
cheesecake-price = (2 * 15) + (0.25 * 36)
```




```
fun cake-price(ingredients-cost, prep-time):
  (2 * ingredients-cost) + (0.25 * prep-time)
end
```

The parameters are the values passed into the function that it needs to know for each operation.

```
fun cake-price(ingredients-cost, prep-time):
  (2 * ingredients-cost) + (0.25 * prep-time)
end
```



```
fun cake-price(ingredients-cost, prep-time):
  (2 * ingredients-cost) + (0.25 * prep-time)
end
```

To calculate the price of chocolate cake or cheesecake, you simply call your function and pass in the relevant values:

```
# Price of chocolate cake
cake-price(10, 20)

# Price of cheesecake
cake-price(15, 36)
```

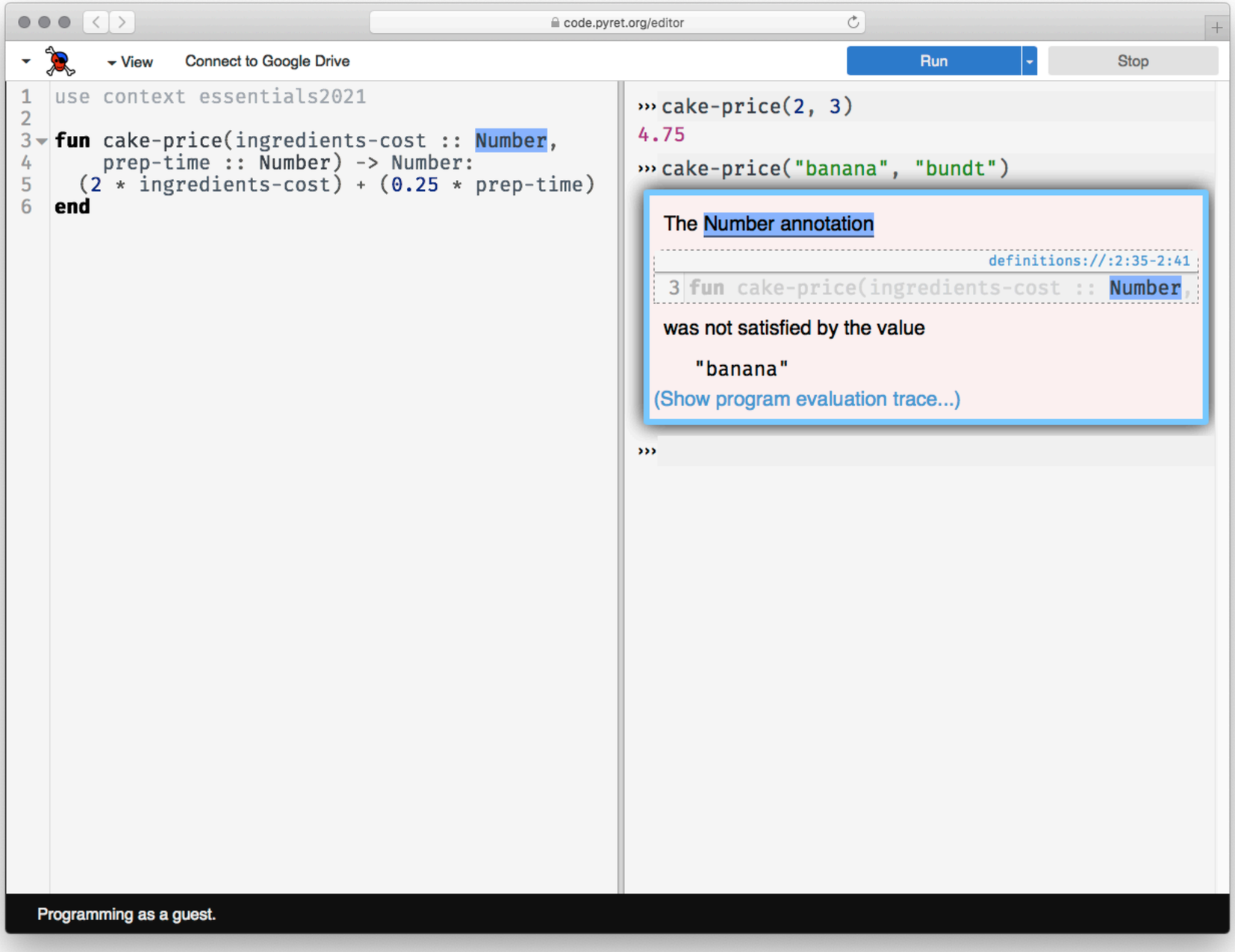
Improving our function definitions

```
fun cake-price(ingredients-cost :: Number,
    prep-time :: Number):
  (2 * ingredients-cost) + (0.25 * prep-time)
end
```

We specify the type of each parameter so that Pyret will check that we pass in the right kind of values, just like for built-in operations like **+** *and* ***above****.*

```
fun cake-price(ingredients-cost :: Number,
    prep-time :: Number) -> Number:
  (2 * ingredients-cost) + (0.25 * prep-time)
end
```

And we can specify the type of value the function returns.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Run
Stop
1 use context essentials2021
2
3 fun cake-price(ingredients-cost :: Number,
4 prep-time :: Number) -> Number:
5 (2 * ingredients-cost) + (0.25 * prep-time)
6 end
››› cake-price(2, 3)
4.75
››› cake-price("banana", "bundt")
The Number annotation
definitions://:2:35-2:41
3 fun cake-price(ingredients-cost :: Number,
was not satisfied by the value
"banana"
(Show program evaluation trace...)
›››
Programming as a guest.

```
fun cake-price(ingredients-cost :: Number,
    prep-time :: Number) -> Number:
  doc: "Calculate price of cake based on
ingredient cost and prep time"
  (2 * ingredients-cost) + (0.25 * prep-time)
end
```

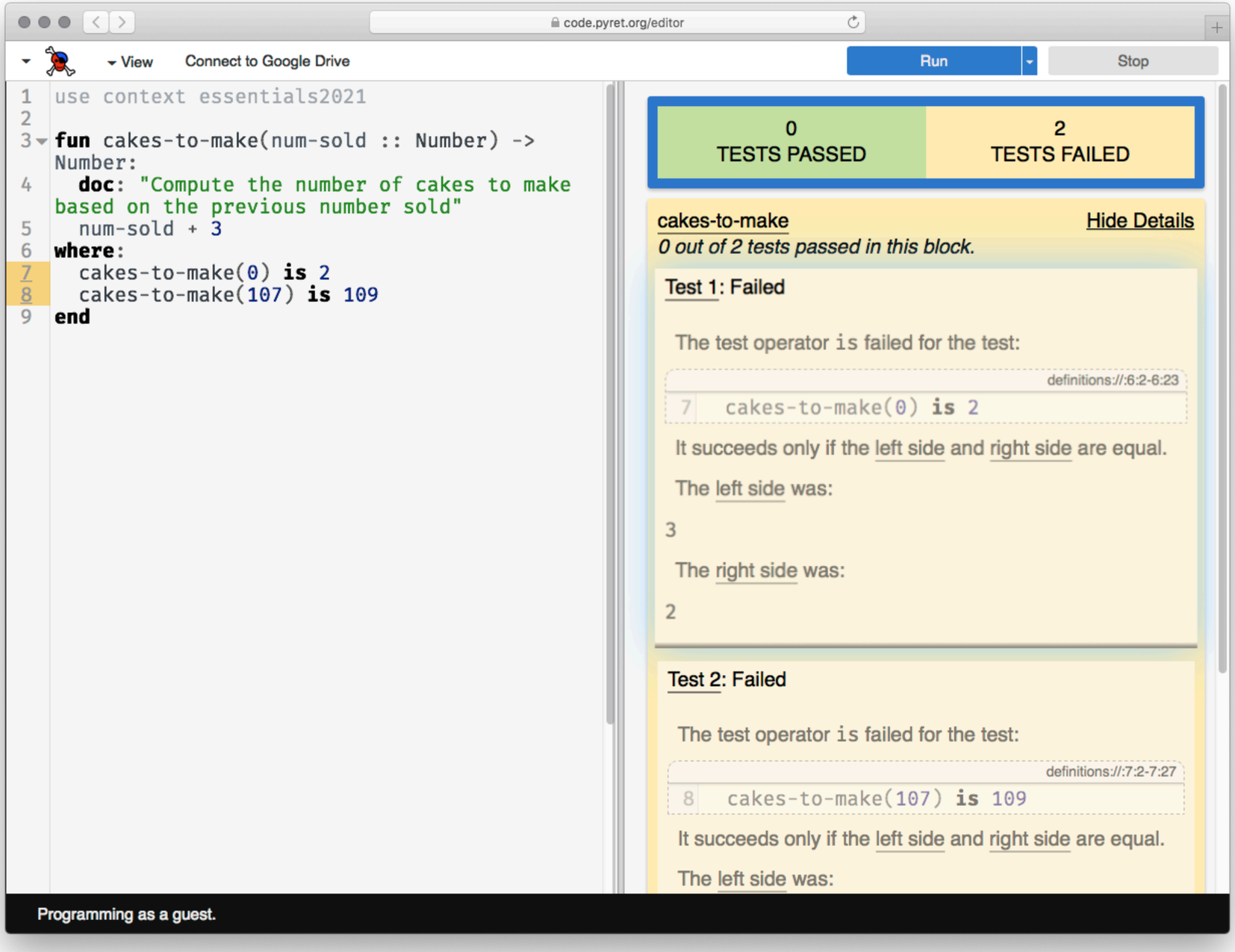
Additionally, a docstring explains what the function does.

“Programs must be written for people to read, and only incidentally for machines to execute.”

Hal Abelson & Gerald Sussman with Julie Sussman, *Structure and Interpretation of Computer Programs*, 1979

```
fun cakes-to-make(num-sold :: Number) -> Number:
  doc: "Compute the number of cakes to make based on
the previous number sold"
  num-sold + 2
end
```

```
fun cakes-to-make(num-sold :: Number) -> Number:
  doc: "Compute the number of cakes to make based on
the previous number sold"
  num-sold + 2
where:
  cakes-to-make(0) is 2
  cakes-to-make(107) is 109
end
```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Run
Stop
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fun cakes-to-make(num-sold :: Number) -> Number:
doc: "Compute the number of cakes to make based on the previous number sold"
num-sold + 3
where:
cakes-to-make(0) is 2
cakes-to-make(107) is 109
end
0
TESTS PASSED
2
TESTS FAILED
cakes-to-make
Hide Details
0 out of 2 tests passed in this block.
Test 1: Failed
The test operator is failed for the test:
definitions://:6:2-6:23
7 cakes-to-make(0) is 2
It succeeds only if the left side and right side are equal.
The left side was:
3
The right side was:
2
Test 2: Failed
The test operator is failed for the test:
definitions://:7:2-7:27
8 cakes-to-make(107) is 109
It succeeds only if the left side and right side are equal.
The left side was:
Programming as a guest.

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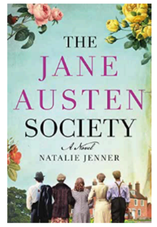

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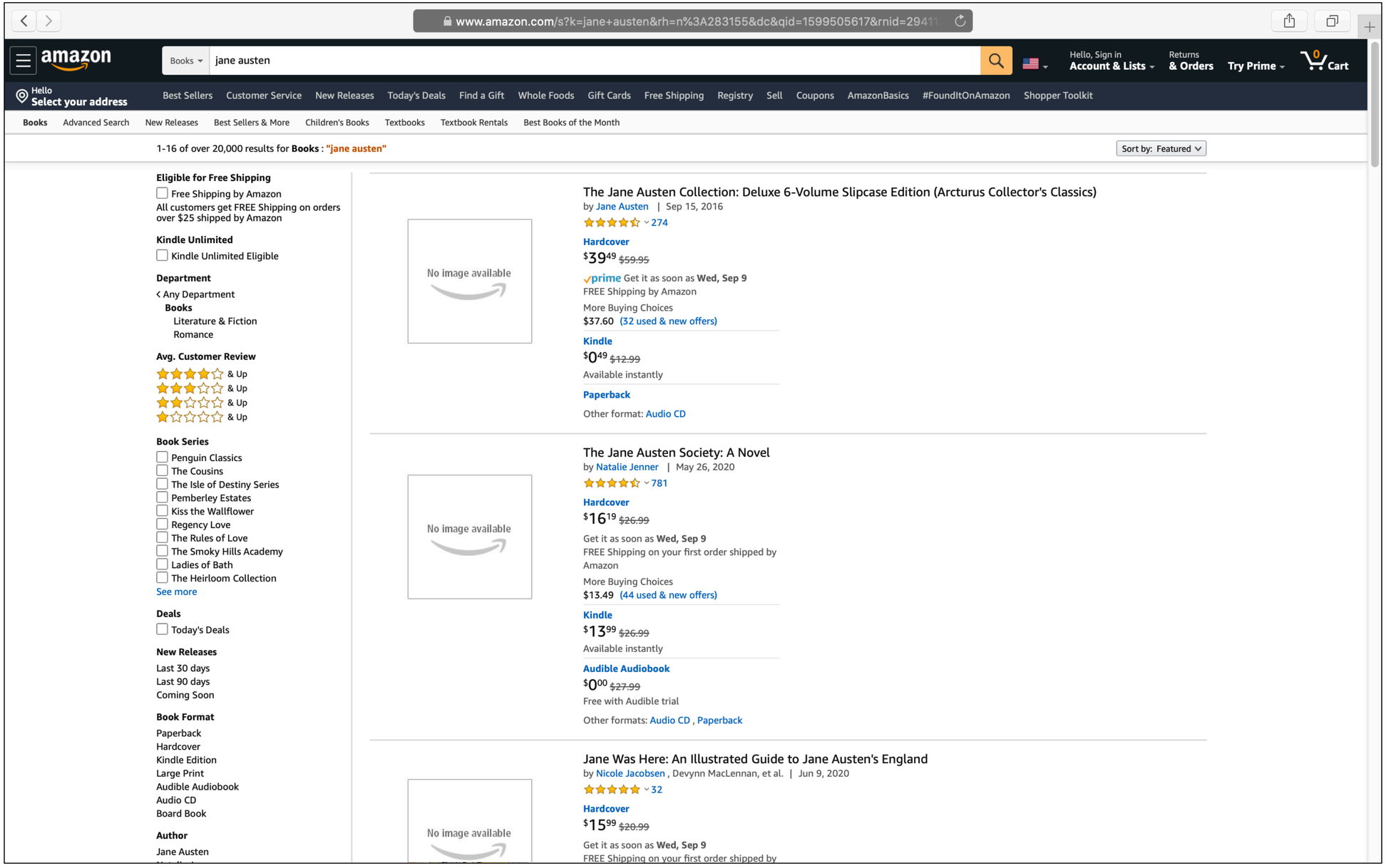
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```
fun rectangle-area(r):
  image-height(r) * image-width(r)
end
```

```
fun rectangle-area(r :: Image) -> Number:
  doc: "Return the rectangular area of the image"
  image-height(r) * image-width(r)
where:
  rectangle-area(rectangle(0, 0, "solid", "black"))
    is 0
  rectangle-area(rectangle(2, 3, "outline", "blue"))
    is 6
end
```

Booleans and `if` expressions

```
true
false
```

To combine Boolean values, we can use **and**:

⟨*expression 1*⟩ `and` ⟨*expression 2*⟩

and **`or`**:

⟨*expression 1*⟩ `or` ⟨*expression 2*⟩

Evaluation of **`and`** stops – is "short-circuited" – as soon as one of the expressions being combined evaluates to `false`.

Evaluation of **`or`** stops as soon as one of the expressions evaluates to `true`.

```
>>> true and false
false
>>> true or false
true
>>> (1 < 2) and (2 > 3)
false
>>> (1 <= 0) or (1 == 1)
true
```

To change an expression that evaluates to `true` to be `false` or vice versa, use **`not`**:

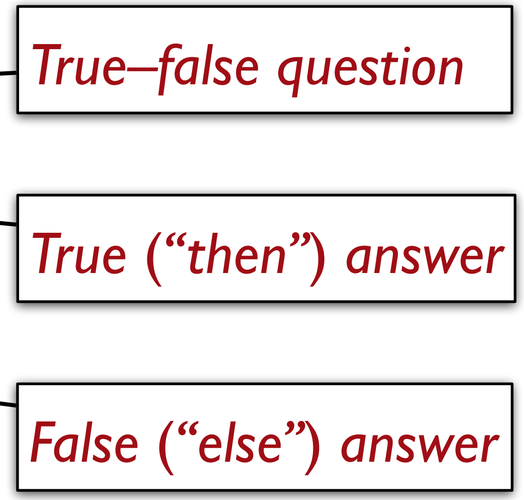
```
>>> not(1 == 0)
true
```

```
i1 = rectangle(10, 20, "solid", "red")
i2 = rectangle(20, 10, "solid", "blue")

image-width(i1) < image-width(i2)
```

```
rect = rectangle(10, 20, "solid", "red")

if image-width(rect) < image-height(rect):
  "tall"
else:
  "wide"
end
```

To form an **`if`** expression:

```
if ⟨expression⟩:
   ⟨expression⟩
else:
   ⟨expression⟩
end
```



Evaluation rule for `if` expressions

1 If the question expression is not a value, evaluate it, and replace with value.

2 If the question is `true`, replace entire **`if`** expression with true answer expression.

3 If the question is `false`, replace entire **`if`** expression with false answer expression.

4 If the question is a value other than true or false, so produce an error.

```
rect = rectangle(10, 20, "solid", "red")

if image-width(rect) < image-height(rect):
  "tall"
else:
  "wide"
end
```

What if, instead of producing a Boolean to say if an image is tall or not, we classify them as "tall", "square", or "wide"?

```
rect = rectangle(10, 20, "solid", "red")

if image-width(rect) < image-height(rect):
  "tall"
else if image-width(rect) == image-height(rect):
  "square"
else:
  "wide"
end
```

```
rect = rectangle(10, 20, "solid", "red")

fun image-type(img :: Image) -> String:
  doc: "Classify an image as tall, square, or wide"
  if image-width(img) < image-height(img):
    "tall"
  else if image-width(img) == image-height(img):
    "square"
  else:
    "wide"
  end
where:
  image-type(rect) is "tall"
end
```

```
rect = rectangle(10, 20, "solid", "red")

fun image-type(img :: Image) -> String:
  doc: "Classify an image as tall, square, or wide"
  if image-width(img) < image-height(img):
    "tall"
  else if image-width(img) == image-height(img):
    "square"
  else:
    "wide"
  end
where:
  image-type(rect) is "tall"
  image-type(rectangle(10, 10, "solid", "blue")) is "square"
  image-type(rectangle(20, 10, "solid", "blue")) is "wide"
end
```

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