Announcements

- Midterm 1 is on Monday 9/23 from 7pm to 9pm
- 2 review sessions on Saturday 9/21 2pm-4pm and 4pm-6pm in 1 Pimentel
- HKN review session on Sunday 9/22 from 4pm to 7pm in 2050 Valley LSB
- Extra weekend office hours announced on Piazza
- Cannot attend? Fill out the conflict form by Friday 9/20 @ 11:59pm!
- No lab next week: Monday 9/23, Tuesday 9/24, or Wednesday 9/25
- Homework 3 due Tuesday 10/1 @ 11:59pm
- Optional Hog strategy contest ends Thursday 10/3 @ 11:59pm

Abstraction

Functional Abstractions

```python
def square(x):
    return pow(x, 2)
def square(x):
    return mul(x, x-1) + x
```

What does `sum_squares` need to know about `square`?

- Square takes one argument.  **Yes**
- Square has the intrinsic name square.  **No**
- Square computes the square of a number.  **Yes**
- Square computes the square by calling mul.  **No**

```python
def square(x):
    return pow(x, 2)
def sum_squares(x, y):
    return square(x) + square(y)
```

If the name "square" were bound to a built-in function, `sum_squares` would still work identically.

Choosing Names

Names typically don’t matter for correctness but they matter a lot for composition

<table>
<thead>
<tr>
<th>From:</th>
<th>To:</th>
</tr>
</thead>
<tbody>
<tr>
<td>true_false</td>
<td>d</td>
</tr>
<tr>
<td>play_helper</td>
<td>num_rolls</td>
</tr>
<tr>
<td>my_int</td>
<td>k, i, n</td>
</tr>
<tr>
<td>1, 1, 0</td>
<td>x, y, z</td>
</tr>
</tbody>
</table>

Names should convey the meaning or purpose of the values to which they are bound.

The type of value bound to the name is best documented in a function’s docstring.

Function names typically convey their effect (print), their behavior (triple), or the value returned (abs).

Which Values Deserve a Name

Repeated compound expressions:

- \( \sqrt{\text{square}(a) + \text{square}(b)} > 1 \):
  \[ x = \sqrt{\text{square}(a) + \text{square}(b)} \]

Hypotenuse = \( \sqrt{\text{square}(a) + \text{square}(b)} \)

If hypotenuse > 1:

\[ x = \text{hypotenuse} \]

Meaningful parts of complex expressions:

\[ x = (b - \sqrt{\text{square}(b) - 4 \times a \times c}) / (2 \times a) \]

\[ \text{discriminant} = \sqrt{\text{square}(b) - 4 \times a \times c} \]

\[ x = (-b - \text{discriminant}) / (2 \times a) \]

More Naming Tips

- Names can be long if they help document your code:
  ```python
  average_age = average(age, students)
  ```
  is preferable to
  ```python
  avg(a, st)
  ```

- Compute average age of students
  ```python
  a = avg(a, st)
  ```

Names can be short if they represent generic quantities: counts, arbitrary functions, arguments to mathematical operations, etc.

\( n, k, l \) - Usually integers
\( x, y, z \) - Usually real numbers
\( f, g, h \) - Usually functions
Test-Driven Development

Write the test of a function before you write the function.

A test will clarify the domain, range, & behavior of a function.
Tests can help identify tricky edge cases.

Develop incrementally and test each piece before moving on.
You can’t depend upon code that hasn’t been tested.
Run your old tests again after you make new changes.

Run your code interactively.

Don’t be afraid to experiment with a function after you write it.
Interactive sessions can become doctests. Just copy and paste.

Function Decorators

Decorators

Why not just use this?

Decorated function

What Would Python Print?

The `print` function returns `None`. It also displays its arguments (separated by spaces) when it is called.

<table>
<thead>
<tr>
<th>This expression</th>
<th>Evaluates to</th>
<th>And prints</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>print(5)</code></td>
<td><code>None</code></td>
<td><code>5</code></td>
</tr>
<tr>
<td><code>print(add(3, 4), print(5))</code></td>
<td><code>7 None</code></td>
<td><code>7 None</code></td>
</tr>
<tr>
<td><code>delay(delay)()(6)()</code></td>
<td><code>None</code></td>
<td><code>delayed delayed</code></td>
</tr>
<tr>
<td><code>delay(print)(4)</code></td>
<td><code>None</code></td>
<td><code>delayed delayed</code></td>
</tr>
<tr>
<td><code>print(delay(print))()</code></td>
<td><code>None</code></td>
<td><code>None</code></td>
</tr>
</tbody>
</table>
What Would Python Print?

The print function returns None. It also displays its arguments (separated by spaces) when it is called.

```
from operator import add, mul

def square(x):
    return mul(x, x)

def pirate(arggg):
    print('matey')

def plunder(arggg):
    return arggg
    return plunder

A function that always returns the identity function

```

A name evaluates to the value bound to that name in the earliest frame of the current environment in which that name is found.

### Example

```
def horse(mask):
    horse = mask

def mask(horse):
    return horse

mask = lambda horse: horse(2)

horse(mask)
```

### Print Function

The print function returns None. It also displays its arguments (separated by spaces) when it is called.

```
print('Hi')
```

### Evaluation Table

<table>
<thead>
<tr>
<th>This expression</th>
<th>Evaluates to</th>
<th>And prints</th>
</tr>
</thead>
<tbody>
<tr>
<td>add(pirate(3)(square)(4), 1)</td>
<td>17</td>
<td>matey</td>
</tr>
<tr>
<td>pirate(pirate(pirate))</td>
<td>Error</td>
<td>matey</td>
</tr>
</tbody>
</table>

### Identity Function

A name evaluates to the value bound to that name in the earliest frame of the current environment in which that name is found.

```
def horse(mask):
    horse = mask

def mask(horse):
    return horse

mask = lambda horse: horse(2)

horse(mask)
```