# 61A Lecture 4

# Announcements

# Iteration Example

# The Fibonacci Sequence

fib

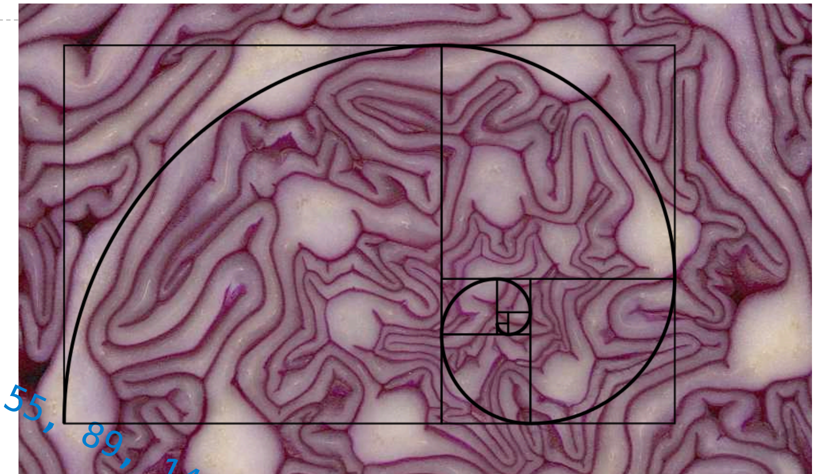
n

predecessor

current

k

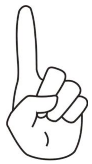
0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987



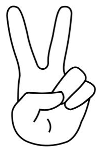
```
def fib(n):
    """Compute the nth Fibonacci number, for N >= 1."""
    pred, curr = 0, 1   # Zeroth and first Fibonacci numbers
    k = 1               # curr is the kth Fibonacci number
    while k < n:
        pred, curr = curr, pred + curr
        k = k + 1
    return curr
```

The next Fibonacci number is the sum of the current one and its predecessor

# Discussion Question 1

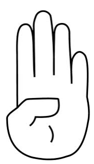


$n^2$

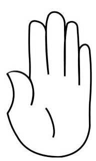


$(n+1)^2$

$2 \cdot (n+1)$



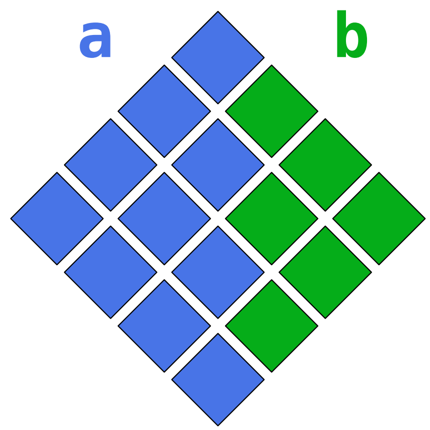
$n^2 + 1$



$n \cdot (n+1)$

What does pyramid compute?

```
def pyramid(n):
    a, b, total = 0, n, 0
    while b:
        a, b = a+1, b-1
        total = total + a + b
    return total
```




# Designing Functions

# Characteristics of Functions

```
def square(x):
    """Return X * X."""
```

```
def fib(n):
    """Compute the nth Fibonacci number, for N >= 1."""
```

A function's domain is the set of all inputs it might possibly take as arguments.

*x is a real number*

*n is an integer greater than or equal to 1*

A function's range is the set of output values it might possibly return.

*returns a non-negative real number*

*returns a Fibonacci number*

A pure function's behavior is the relationship it creates between input and output.

*return value is the square of the input*

*return value is the nth Fibonacci number*

# A Guide to Designing Function

Give each function exactly one job.

**not**

Don’t repeat yourself (DRY). Implement a process just once, but execute it many times.

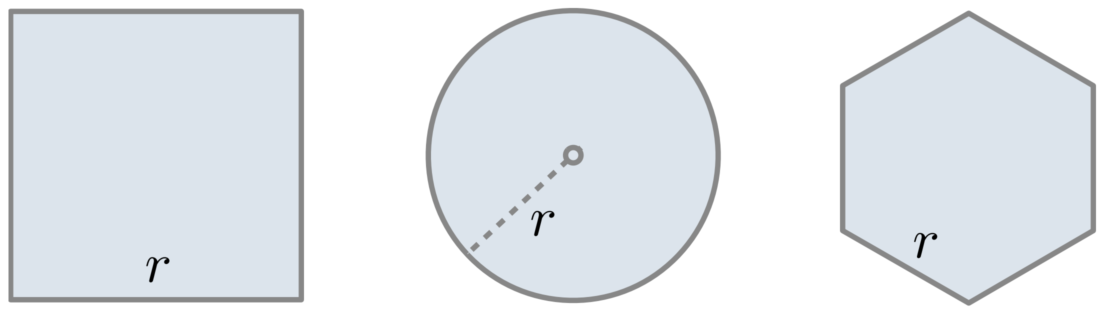
Define functions generally.

# Generalization

# Generalizing Patterns with Arguments

Regular geometric shapes relate length and area.

**Shape:**




**Area:** $\boxed{1} \cdot r^2$ $\qquad$ $\boxed{\pi} \cdot r^2$ $\qquad$ $\boxed{\frac{3\sqrt{3}}{2}} \cdot r^2$

Finding common structure allows for shared implementation

(Demo)

# Higher-Order Functions

# Generalizing Over Computational Processes

```
The common structure among functions may be a computational process, rather than a number.
```

$$\sum_{k=1}^{5} \boxed{k} = 1 + 2 + 3 + 4 + 5 \qquad = 15$$

$$\sum_{k=1}^{5} \boxed{k^3} = 1^3 + 2^3 + 3^3 + 4^3 + 5^3 \qquad = 225$$

$$\sum_{k=1}^{5} \boxed{\frac{8}{(4k-3)\cdot(4k-1)}} = \frac{8}{3} + \frac{8}{35} + \frac{8}{99} + \frac{8}{195} + \frac{8}{323} \qquad = 3.04$$

```
(Demo)
```

# Summation Example

```python
def cube(k):
    return pow(k, 3)

def summation(n, term):
    """Sum the first n terms of a sequence.

    >>> summation(5, cube)
    225
    """
    total, k = 0, 1
    while k <= n:
        total, k = total + term(k), k + 1
    return total
```

Function of a single argument (*not called* "*term*")

A formal parameter that will be bound to a function

The cube function is passed as an argument value

0 + 1 + 8 + 27 + 64 + 125

The function bound to term gets called here

# Functions as Return Values

(Demo)

# Locally Defined Functions

Functions defined within other function bodies are bound to names in a local frame

A function that returns a function

```
def make_adder(n):
    """Return a function that takes one argument k and returns k + n.

    >>> add_three = make_adder(3)
    >>> add_three(4)
    7
    """
    def adder(k):
        return k + n
    return adder
```

The name add_three is bound to a function

A def statement within another def statement

Can refer to names in the enclosing function

# Call Expressions as Operator Expressions