Announcements
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• Homework 9 due Tuesday 11/19 @ 11:59pm
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• Homework 9 due Tuesday 11/19 @ 11:59pm
• Project 4 due Thursday 11/21 @ 11:59pm
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• Project 4 due Thursday 11/21 @ 11:59pm
• Extra reader office hours in 405 Soda this week
  • Monday: 5pm–6:30pm
  • Tuesday: 6pm–7:30pm
  • Wednesday: 5:30pm–7pm
  • Thursday: 5:30pm–7pm
Information Hiding
Attributes for Internal Use

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class FibIter:
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    def __init__(self):
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>>> fibs = FibIter()
>>> [next(fibs) for _ in range(10)]
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This naming convention is not enforced, but is typically respected.

A programmer who designs and maintains a public module may change internal-use names.
Starting a name with two underscores enforces restricted access from outside the class.
Names in Local Scope

A name bound in a local frame is not accessible to other environments, except those that extend the frame.
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```python
def fib_generator():
    """A generator function for Fibonacci numbers."

    >>> fibs = fib_generator()
    >>> [next(fibs) for _ in range(10)]
    [0, 1, 1, 2, 3, 5, 8, 13, 21, 34]
    """
    yield 0
    previous, current = 0, 1
    while True:
        yield current
        previous, current = current, previous + current
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    """
    yield 0
    previous, current = 0, 1
    while True:
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        previous, current = current, previous + current
```

There is no way to access values bound to "previous" and "current" externally
Singleton Objects
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**NoneType**, the class of **None**, is a singleton class. None is its only instance.
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```python
class empty_iterator:
    """An iterator over no values.""
    def __next__(self):
        raise StopIteration
    empty_iterator = empty_iterator()
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The instance  The class
Streams
Streams are Lazy Recursive Lists

A stream is a recursive list, but the rest of the list is computed on demand.
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Rlist( _________________ , _________________ )
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Rlist( _____________ , ________________ )

First element can be anything
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Rlist( __________________ , __________________ )

- First element can be anything
- Second element is an Rlist or Rlist.empty
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Once created, Streams and Rlists can be used interchangeably using first and rest methods.
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Once created, Streams and Rlists can be used interchangeably using \textit{first} and \textit{rest} methods.

(Demo)
An integer stream is a stream of consecutive integers.

An integer stream starting at first is constructed from first and a function compute_rest that returns the integer stream starting at first+1.
Integer Stream

An integer stream is a stream of consecutive integers.

An integer stream starting at `first` is constructed from `first` and a function `compute_rest` that returns the integer stream starting at `first+1`.

```python
def integer_stream(first=1):
    """Return a stream of consecutive integers, starting with first."
    >>> s = integer_stream(3)
    >>> s.first
    3
    >>> s.rest.first
    4
    """
    def compute_rest():
        return integer_stream(first+1)
    return Stream(first, compute_rest)
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(Demo)
Stream Processing
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Stream Implementation
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class empty:
    def __repr__(self):
        return 'Stream.empty'
empty = empty()
Stream Implementation

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class Stream:
    """A lazily computed recursive list."""
    class empty:
        def __repr__(self):
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    empty = empty()

def __init__(self, first, compute_rest=lambda: Stream.empty):
    assert callable(compute_rest), 'compute_rest must be callable.'
    self.first = first
    self._compute_rest = compute_rest
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@property
def rest(self):
    """Return the rest of the stream, computing it if necessary."""
    if self._compute_rest is not None:
        self._rest = self._compute_rest()
        self._compute_rest = None
    return self._rest
Higher-Order Functions on Streams
Mapping a Function over a Stream
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Mapping a function over a stream applies a function only to the first element right away. The rest is computed lazily.
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```python
def map_stream(fn, s):
    """Map a function fn over the elements of a stream s."""
    if s is Stream.empty:
        return s
    def compute_rest():
        return map_stream(fn, s.rest)
    return Stream(fn(s.first), compute_rest)
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This body is not executed until `compute_rest` is called.
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```

```python
>>> s = integer_stream(3)
>>> s
Stream(3, <...>)
>>> m = map_stream(lambda x: x*x, s)
>>> first_k(m, 5)
[9, 16, 25, 36, 49]
```
Filtering a Stream
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def filter_stream(fn, s):
    """Filter stream s with predicate function fn."""
    if s is Stream.empty:
        return s
    def compute_rest():
        return filter_stream(fn, s.rest)
    if fn(s.first):
        return Stream(s.first, compute_rest)
    else:
        return compute_rest()
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Actually compute the rest
A Stream of Primes
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