Data Examples

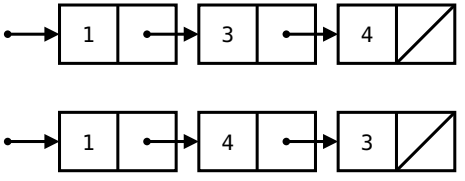
Class outline:

- Linked lists
- Lists
- Objects

Linked lists

Exercise: Is it ordered?

Is a linked list ordered from least to greatest?

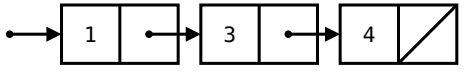


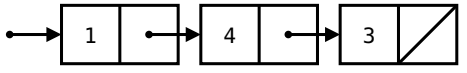

```
def ordered(s):
    """Is Link s ordered?

    >>> ordered(Link(1, Link(3, Link(4))))
    True
    >>> ordered(Link(1, Link(4, Link(3))))
    False
    >>> ordered(Link(1, Link(-3, Link(4))))
    False
    """
```

Exercise: Is it ordered? (Solution)

Is a linked list ordered from least to greatest?



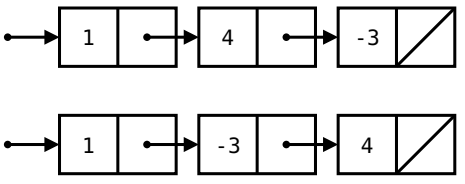



```
def ordered(s, key=lambda x: x):
    """Is Link s ordered?

    >>> ordered(Link(1, Link(3, Link(4))))
    True
    >>> ordered(Link(1, Link(4, Link(3))))
    False
    >>> ordered(Link(1, Link(-3, Link(4))))
    False
    """
    if s is Link.empty or s.rest is Link.empty:
        return True
    elif s.first > s.rest.first:
        return False
    else:
        return ordered(s.rest)
```

Exercise: Is it ordered? Part 2

Is it ordered when a key function is applied, like `abs`?

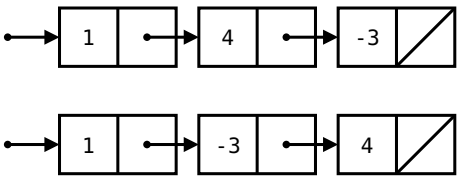



```
def ordered(s, key=lambda x: x):
    """Is Link s ordered?

    >>> ordered(Link(1, Link(3, Link(4))))
    True
    >>> ordered(Link(1, Link(4, Link(3))))
    False
    >>> ordered(Link(1, Link(-3, Link(4))))
    False
    >>> ordered(Link(1, Link(-3, Link(4))), key=abs)
    True
    >>> ordered(Link(-4, Link(-1, Link(3))))
    True
    >>> ordered(Link(-4, Link(-1, Link(3))), key=abs)
    False
    """
```

Exercise: Is it ordered? Part 2 (Solution)

Is it ordered when a key function is applied, like `abs`?

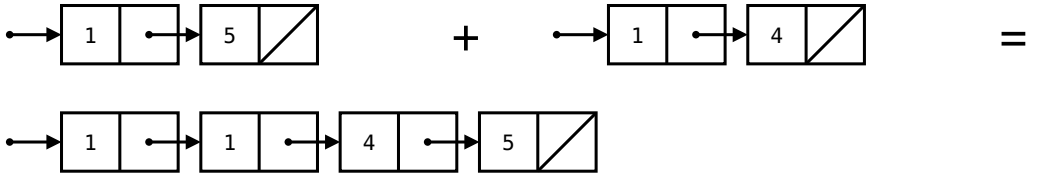



```
def ordered(s, key=lambda x: x):
    """Is Link s ordered?

    >>> ordered(Link(1, Link(3, Link(4))))
    True
    >>> ordered(Link(1, Link(4, Link(3))))
    False
    >>> ordered(Link(1, Link(-3, Link(4))))
    False
    >>> ordered(Link(1, Link(-3, Link(4))), key=abs)
    True
    >>> ordered(Link(-4, Link(-1, Link(3))))
    True
    >>> ordered(Link(-4, Link(-1, Link(3))), key=abs)
    False
    """
    if s is Link.empty or s.rest is Link.empty:
        return True
    elif key(s.first) > key(s.rest.first):
        return False
    else:
        return ordered(s.rest)
```

Exercise: Sorted merged list

Create a sorted Link containing all the elements of two sorted Links.

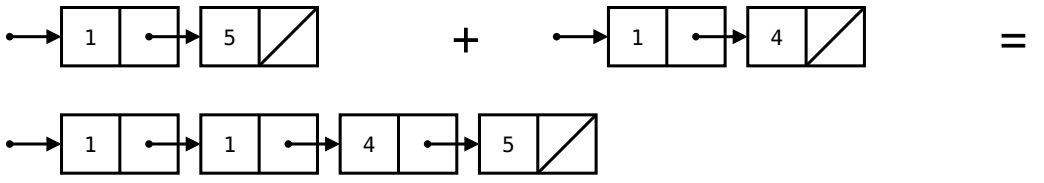



```
def merge(s, t):
    """Return a sorted Link containing the elements of sorted s & t.

    >>> a = Link(1, Link(5))
    >>> b = Link(1, Link(4))
    >>> merge(a, b)
    Link(1, Link(1, Link(4, Link(5))))
    >>> a
    Link(1, Link(5))
    >>> b
    Link(1, Link(4))
    """
```

Exercise: Sorted merged list (Solution)

Create a sorted Link containing all the elements of two sorted Links.

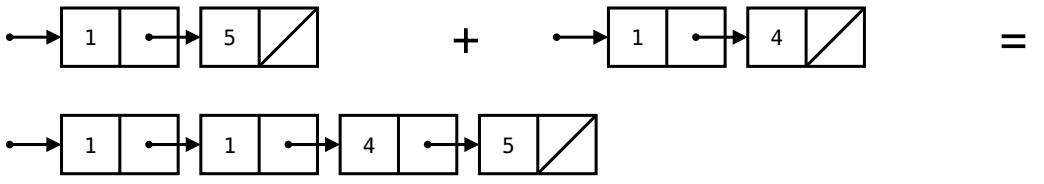



```
def merge(s, t):
    """Return a sorted Link containing the elements of sorted s & t.

    >>> a = Link(1, Link(5))
    >>> b = Link(1, Link(4))
    >>> merge(a, b)
    Link(1, Link(1, Link(4, Link(5))))
    >>> a
    Link(1, Link(5))
    >>> b
    Link(1, Link(4))
    """
    if s is Link.empty:
        return t
    elif t is Link.empty:
        return s
    elif s.first <= t.first:
        return Link(s.first, merge(s.rest, t))
    else:
        return Link(t.first, merge(s, t.rest))
```

Exercise: Sorted merged list II

This time, do it without creating any new `Link` objects.

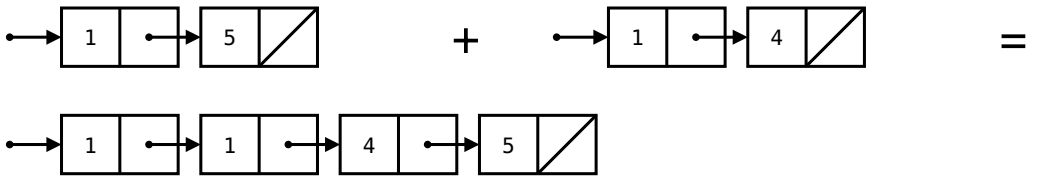



```
def merge_in_place(s, t):
    """Return a sorted Link containing the elements of sorted s & t.

    >>> a = Link(1, Link(5))
    >>> b = Link(1, Link(4))
    >>> merge_in_place(a, b)
    Link(1, Link(1, Link(4, Link(5))))
    >>> a
    Link(1, Link(1, Link(4, Link(5))))
    >>> b
    Link(1, Link(4, Link(5)))
    """
```

Exercise: Sorted merged list II (Solution)

This time, do it without creating any new `Link` objects.




```
def merge_in_place(s, t):
    """Return a sorted Link containing the elements of sorted s & t.

    >>> a = Link(1, Link(5))
    >>> b = Link(1, Link(4))
    >>> merge_in_place(a, b)
    Link(1, Link(1, Link(4, Link(5))))
    >>> a
    Link(1, Link(1, Link(4, Link(5))))
    >>> b
    Link(1, Link(4, Link(5)))
    """
    if s is Link.empty:
        return t
    elif t is Link.empty:
        return s
    elif s.first <= t.first:
        s.rest = merge_in_place(s.rest, t)
        return s
    else:
        t.rest = merge_in_place(s, t.rest)
        return t
```

Iterables & Iterators

Exercise: Find indices

What are the indices of all elements in a list that have the smallest absolute value?

```
[-4, -3, -2,  3,  2,  4]  → [2, 4]
  0   1   2   3   4   5
```

```
[ 1,  2,  3,  4,  5,  6]  → [0]
  0   1   2   3   4   5
```

```
def min_abs_indices(s):
    """Indices of all elements in list s that have the smallest absolute value.

    >>> min_abs_indices([-4, -3, -2, 3, 2, 4])
    [2, 4]
    >>> min_abs_indices([1, 2, 3, 4, 5])
    [0]
    """
```

Exercise: Find indices (Solution)

What are the indices of all elements in a list that have the smallest absolute value?

```
[-4, -3, -2,  3,  2,  4]  → [2, 4]
  0   1   2   3   4   5
```

```
[ 1,  2,  3,  4,  5,  6]  → [0]
  0   1   2   3   4   5
```

```
def min_abs_indices(s):
    """Indices of all elements in list s that have the smallest absolute value.

    >>> min_abs_indices([-4, -3, -2, 3, 2, 4])
    [2, 4]
    >>> min_abs_indices([1, 2, 3, 4, 5])
    [0]
    """
    min_abs = min(map(abs, s))
    return list(filter(lambda i: abs(s[i]) == min_abs, range(len(s))))
    # OR
    return [i for i in range(len(s)) if abs(s[i]) == min_abs]
```

Exercise: Largest sum

What's the largest sum of two adjacent elements in a list? (Assume length > 1)

```
[-4,  -3,  -2,   3,   2,   4]  → 6
   -7    -5    1    5    6
```

```
[-4,   3,  -2,  -3,   2,   -4]  → 1
   -1    1    -5   -1   -2
```

```
def largest_adj_sum(s):
    """Largest sum of two adjacent elements in a list s.

    >>> largest_adj_sum([-4, -3, -2, 3, 2, 4])
    6
    >>> largest_adj_sum([-4, 3, -2, -3, 2, -4])
    1
    """
```

Exercise: Largest sum (Solution)

What's the largest sum of two adjacent elements in a list? (Assume length > 1)

```
[-4,  -3,  -2,   3,   2,   4]  → 6
   -7    -5    1    5    6
```

```
[-4,   3,  -2,  -3,   2,   -4]  → 1
   -1    1    -5   -1   -2
```

```
def largest_adj_sum(s):
    """Largest sum of two adjacent elements in a list s.

    >>> largest_adj_sum([-4, -3, -2, 3, 2, 4])
    6
    >>> largest_adj_sum([-4, 3, -2, -3, 2, -4])
    1
    """
    return max([x + y for x, y in zip(s[:-1], s[1:])])
    # OR
    return max([s[i] + s[i + 1] for i in range(len(s) - 1)])
    # OR
    return max(map(lambda i: s[i] + s[i + 1], range(len(s) - 1)))
```

Exercise: Digits dictionary

Create a dictionary mapping each digit d to the lists of elements in s that end with d.

```
[5, 8, 13, 21, 34, 55, 89] → {1: [21], 3: [13], 4: [34], 5: [5, 55], 8: [8], 9: [89]}
```

```
def digit_dict(s):
    """Map each digit d to the lists of elements in s that end with d.

    >>> digit_dict([5, 8, 13, 21, 34, 55, 89])
    {1: [21], 3: [13], 4: [34], 5: [5, 55], 8: [8], 9: [89]}
    """
```

Exercise: Digits dictionary (Solution)

Create a dictionary mapping each digit d to the lists of elements in s that end with d.

```
[5, 8, 13, 21, 34, 55, 89] → {1: [21], 3: [13], 4: [34], 5: [5, 55], 8: [8], 9: [89]}
```

```
def digit_dict(s):
    """Map each digit d to the lists of elements in s that end with d.

    >>> digit_dict([5, 8, 13, 21, 34, 55, 89])
    {1: [21], 3: [13], 4: [34], 5: [5, 55], 8: [8], 9: [89]}
    """
    return {i: [x for x in s if x % 10 == i]
            for i in range(10) if any([x % 10 == i for x in s])}
    # OR
    last_digits = list(map(lambda x: x % 10, s))
    return {i: [x for x in s if x % 10 == i]
            for i in range(10) if i in last_digits}
```

Exercise: Element comparer

Does every element equal some other element in s?

```
[-4, -3, -2, 3, 2, 4] → False
[4, 3, 2, 3, 2, 4]    → True
```

```
def all_have_an_equal(s):
    """Does every element equal some other element in s?

    >>> all_have_an_equal([-4, -3, -2, 3, 2, 4])
    False
    >>> all_have_an_equal([4, 3, 2, 3, 2, 4])
    True
    """
```

Exercise: Element comparer (Solution)

Does every element equal some other element in s?

```
[-4, -3, -2, 3, 2, 4] → False
[4, 3, 2, 3, 2, 4]    → True
```

```
def all_have_an_equal(s):
    """Does every element equal some other element in s?

    >>> all_have_an_equal([-4, -3, -2, 3, 2, 4])
    False
    >>> all_have_an_equal([4, 3, 2, 3, 2, 4])
    True
    """
    return min([sum([1 for y in s if x == y]) for x in s]) > 1
    # OR
    return all([s[i] in s[:i] + s[i+1:] for i in range(len(s))])
    # OR
    return all(map(lambda x: s.count(x) > 1, s))
```

Lists in environment diagrams

List operations

Starting from:

```
s = [2, 3]
t = [5, 6]
```

Operation	Example	Result
`append` adds one element to a list	`s.append(t)` `t = 0`	
`extend` adds all elements in one list to another list	`s.extend(t)` `t[1] = 0`	

addition & slicing create new lists containing existing elements	`a = s + [t]`
	`b = a[1:]`
	`a[1] = 9`
	`b[1][1] = 0`	

List operations

Starting from:

```
s = [2, 3]
t = [5, 6]
```

Operation	Example	Result
`append` adds one element to a list	`s.append(t)` `t = 0`	`s → [2, 3, [5, 6]]` `t → 0`
`extend` adds all elements in one list to another list	`s.extend(t)` `t[1] = 0`	

addition & slicing create new lists containing existing elements	`a = s + [t]`
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List operations

Starting from:

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```

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`extend` adds all elements in one list to another list	`s.extend(t)` `t[1] = 0`	`s → [2, 3, 5, 6]` `t → [5, 0]`

addition & slicing create new lists containing existing elements	`a = s + [t]`
	`b = a[1:]`
	`a[1] = 9`
	`b[1][1] = 0`	

List operations

Starting from:

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s = [2, 3]
t = [5, 6]
```

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`append` adds one element to a list	`s.append(t)` `t = 0`	`s → [2, 3, [5, 6]]` `t → 0`
`extend` adds all elements in one list to another list	`s.extend(t)` `t[1] = 0`	`s → [2, 3, 5, 6]` `t → [5, 0]`

addition & slicing create new lists containing existing elements	`a = s + [t]`
	`b = a[1:]`
	`a[1] = 9`
	`b[1][1] = 0`
		`s → [2, 3]`
		`t → [5, 0]`
		`a → [2, 9, [5, 0]]`
		`b → [3, [5, 0]]`

List operations

Starting from:

```
s = [2, 3]
t = [5, 6]
```

Operation	Example	Result
The `list` constructor also creates a new list containing existing elements	`t = list(s)` `s[1] = 0`	

slice assignment replaces a slice with new values	`s[0:0] = t`
	`s[3:] = t`
	`t[1] = 0`	

List operations

Starting from:

```
s = [2, 3]
t = [5, 6]
```

Operation	Example	Result
The `list` constructor also creates a new list containing existing elements	`t = list(s)` `s[1] = 0`	`s → [2, 0]` `t → [2, 3]`

slice assignment replaces a slice with new values	`s[0:0] = t`
	`s[3:] = t`
	`t[1] = 0`	

List operations

Starting from:

```
s = [2, 3]
t = [5, 6]
```

Operation	Example	Result
The `list` constructor also creates a new list containing existing elements	`t = list(s)` `s[1] = 0`	`s → [2, 0]` `t → [2, 3]`

slice assignment replaces a slice with new values	`s[0:0] = t`
	`s[3:] = t`
	`t[1] = 0`
		`s → [5, 6, 2, 5, 6]`
		`t → [5, 0]`

Lists in lists

```
t = [1, 2, 3]
t[1:3] = [t]
t.extend(t)
```

View in PythonTutor

```
t = [[1, 2], [3, 4]]
t[0].append(t[1:2])
```

View in PythonTutor

Objects

Santa's helpers

```
class Elf:
    greeting = 'Boss'
    def __init__(self):
        self.shelf = Elf
    def work(self):
        return self.greeting + ', I toil all day'
    def __repr__(self):
        return Santa.greeting

class Santa(Elf):
    greeting = 'Elfie'
    def work(self):
        print(Elf.work(self))
        return 'My job is to break into kid\'s homes!'

jack = Elf()
klaus = Santa()
jack.greeting = 'Your Jollyness'
```

```
>>> Elf().work()

>>> jack
```

```
>>> jack.work()

>>> klaus.work()


>>> klaus.shelf.work(klaus)
```

Santa's helpers

```
class Elf:
    greeting = 'Boss'
    def __init__(self):
        self.shelf = Elf
    def work(self):
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        return 'My job is to break into kid\'s homes!'

jack = Elf()
klaus = Santa()
jack.greeting = 'Your Jollyness'
```

```
>>> Elf().work()
'Boss, I toil all day'
>>> jack
```

```
>>> jack.work()

>>> klaus.work()


>>> klaus.shelf.work(klaus)
```

Santa's helpers

```
class Elf:
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klaus = Santa()
jack.greeting = 'Your Jollyness'
```

```
>>> Elf().work()
'Boss, I toil all day'
>>> jack
Elfie
```

```
>>> jack.work()

>>> klaus.work()


>>> klaus.shelf.work(klaus)
```

Santa's helpers

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jack = Elf()
klaus = Santa()
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```

```
>>> Elf().work()
'Boss, I toil all day'
>>> jack
Elfie
```

```
>>> jack.work()
'Your Jollyness, I toil all day'
>>> klaus.work()


>>> klaus.shelf.work(klaus)
```

Santa's helpers

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class Elf:
    greeting = 'Boss'
    def __init__(self):
        self.shelf = Elf
    def work(self):
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    def __repr__(self):
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```

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>>> Elf().work()
'Boss, I toil all day'
>>> jack
Elfie
```

```
>>> jack.work()
'Your Jollyness, I toil all day'
>>> klaus.work()
Elfie, I toil all day

>>> klaus.shelf.work(klaus)
```

Santa's helpers

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```

```
>>> Elf().work()
'Boss, I toil all day'
>>> jack
Elfie
```

```
>>> jack.work()
'Your Jollyness, I toil all day'
>>> klaus.work()
Elfie, I toil all day
"My job is to break into kid's homes!"
>>> klaus.shelf.work(klaus)
```

Santa's helpers

```
class Elf:
    greeting = 'Boss'
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```

```
>>> Elf().work()
'Boss, I toil all day'
>>> jack
Elfie
```

```
>>> jack.work()
'Your Jollyness, I toil all day'
>>> klaus.work()
Elfie, I toil all day
"My job is to break into kid's homes!"
>>> klaus.shelf.work(klaus)
'Elfie, I toil all day'
```

Python Project of The Day!

Outreachy

Outreachy: An organization that provides internships in open source to people subject to systemic bias and impacted by underrepresentation in the technical industry where they are living.

Website written in Django, a popular Python web framework.

Github repository