Lecture 03
Iteration in Python

based in part on notes from the CS-for-All curriculum developed at Harvey Mudd College

Last Time (lecture 02)

- Conditional Statements and Flow of Control
  - `if`
  - `if-else`
  - `if-elif-else`
  - True/False Blocks (require indentation)
- Variable Scope
  - Local
  - Global
- Memory: Frames and the Stack
  - Tracing global, local, and printed output
  - Functions calling Functions

Review
Default Index/Slicing Values

```
s == s[:]
s[:] = s[::]
s[::] = s[0:len(s):1]
s[len(s):] == ''

s='01234'  # len(s) == 5
s[2:] == s[ ?? : ?? : ?? ]
s[:3] == s[    :    :   ]
s[::2] == s[    :    :   ]
s[:4:3] == s[    :    :   ]
s[1::2] == s[    :    :   ]
```

Review
Default Index/Slicing Values

```
s == s[:]
s[:] = s[::]
s[::] = s[0:len(s):1]
s[len(s):] == ''

s='01234'  # len(s) == 5
s[2:] == s[2:5:1]
s[:3] == s[0:3:1]
s[::2] == s[0:5:2]
s[:4:3] == s[0:4:3]
s[1::2] == s[1:5:2]
```

Lecture 03 Goals

- Introduce Test Driven Design (TDD)
- Iteration
  - Definite vs. Indefinite looping
- **for** loops
  - Element-based vs. Index-based
- List comprehensions
  - Generative vs. Manipulative
  - Uniform vs. Conditional

Test Driven Design

When coding

1. Think clearly about how each function should work
   - Inputs(what are arguments)
   - Outputs (what should be returned)
   - Special cases
   - Usual cases
2. Develop a function signature (def + docstring)
3. Write actual “test cases” before you start to code each function
4. Add/improve tests as needed

This approach is also known as *Test First Design*.

Test Driven Design Example

Write a function gap(x,y) that returns the distance between the numbers x and y? Use **if** statements and not a function like **abs** or **max**.

1. Think clearly about how each function should work
   - Inputs (what are arguments)

     Two numbers, x and y
   - Outputs (what should be returned)

     The distance between x and y, i.e. |x-y|
   - Special cases

     If x==y, must return 0
   - Usual cases

     x > y or x < y

Test Driven Design Example

Write a function gap(x,y) that returns the distance between the numbers x and y? Use **if** statements and not a function like **abs** or **max**.

2. Develop a function signature (def + docstring)

```
def gap(x,y):
    '''Returns distance between two input numbers.'''
```

NOTE: The doc string should explain what the function does (and how to use it, i.e. inputs, outputs) but NOT how it does it.

Test Driven Design Example

Write a function gap(x,y) that returns the distance between the numbers x and y? Use **if** statements and not a function like **abs** or **max**.

3. Write actual "test cases" before you start code each function
   - Special cases: x==y must return 0
   - Usual case: x > y, x < y
   - Note the test cases go in a new function

```
def gap_test():
    assert gap(10,10)==0, 'x==y test failed'
    assert gap(1, 10)==9, 'x<y test failed'
    assert gap(15,13)==2, 'x>y test failed'
```

Improving Tests

4. Add/improve tests as needed

- Creating student accounts for CS department machines
- The code was tested and it worked, but it failed to account for cases where there were two sections of the class on CAB (CS 4)
- **Edge case-** a case that will rarely happen, but your program should still be able to handle it
- For CS logins, add test to make sure it works for class with two sections

Test Driven Design

Now code/test your function, design will be informed by tests that need to pass.

```
def gap_test():
    assert gap(10,10)==0, 'x==y test failed'
    assert gap(1, 10)==9, 'x<y test failed'
    assert gap(15,13)==2, 'x>y test failed'

def gap(x, y): # Fill in after first set of tests!
    ''' Returns the distance between two input numbers.'''
    if x > y:
        return x - y
    else:
        return y - x
```

```
gap_test()
```

As you proceed keep testing,

4. Add/improve tests as needed

Test Driven Design, In class Problem

Write a function called **repeat_element(string, index, num_times)** that takes as input a string, the index of the element that we want to repeat, and the number of times we want to repeat. The function should return a new string in which the element of the string at position index is repeated **num_times** times.

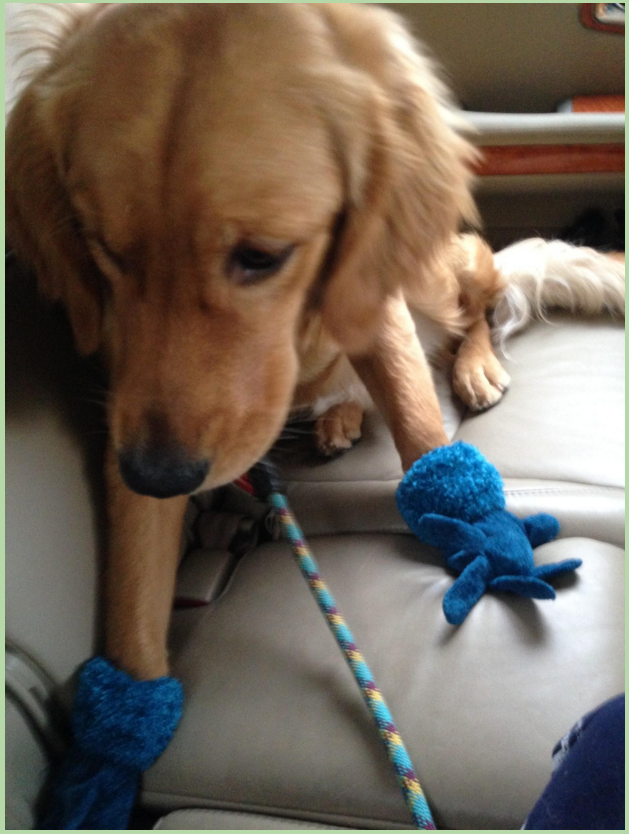
1. Think clearly about how each function should work
   - Inputs(what are arguments)
   - Outputs (what should be returned)
   - Special cases
   - Usual cases
2. Develop a function signature (def + docstring)
3. Write actual "test cases" before you start to code each function.

Iteration: Loops

- A loop is a sequence of *instructions* to be repeated
- Definite and Indefinite
  - Definite: repeat exactly X times
  - Indefinite: repeat until some condition changes

This is Bijou. Bijou is demonstrating the following iteration examples:

```
for every front paw
        paw = paw + frilly blue glove
while sun == shining
        shed_more_fur()
```



Definite Loops

based in part on notes from the CS-for-All curriculum developed at Harvey Mudd College

`for` Loops

- A **`for`** statement is one way to create a loop in Python.
  - allows us to *repeat* statements a specific number of times
- Example:

```
for i in [1, 2, 3]:
 print('Warning')
    print(i)
```

"body"

will output:

```
Warning
1
Warning
2
Warning
3
```

- The repeated statement(s) are known as the *body* of the loop.
  - must be indented the same amount in Python

for Loops (cont.)

- General syntax:

```
for <variable> in <sequence>:
        <body of the loop>
```

```
for i in [1, 2, 3]:
    print('Warning')
    print(i)
```

- In this case, our sequence is a sequence of *values*, but it could be *any* sequence (i.e. `for word in list_of_words`)

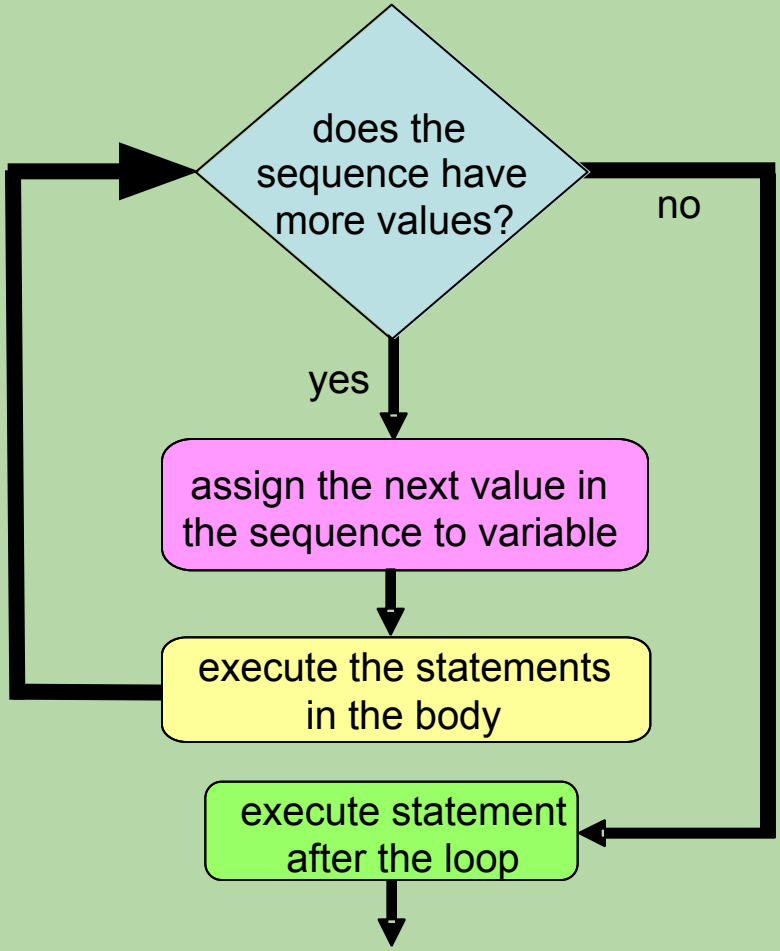
- For each value in the sequence:
  - the value is assigned to the variable
  - all statements in the body of the loop are executed using that value

- Once all values in the sequence have been processed, the program continues with the first statement after the loop.

Executing a `for` Loop

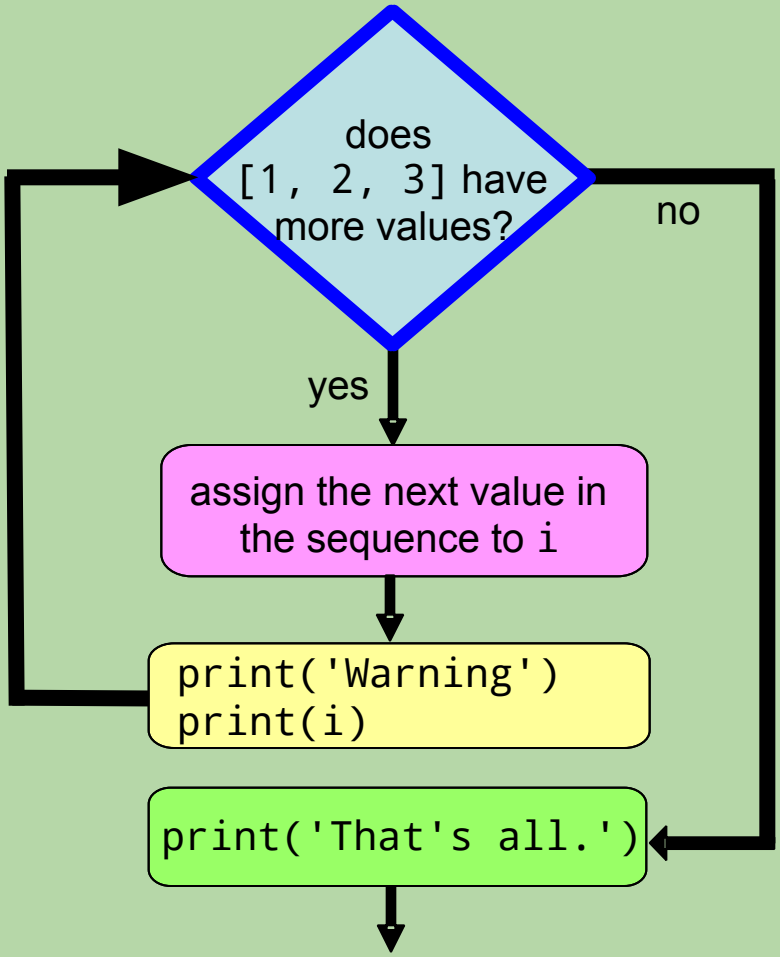
```
for <variable> in <sequence>:
        <body of the loop>
```

```
for i in [1, 2, 3]:
    print('Warning')
    print(i)
```



Executing Our Earlier Example
(with one extra statement)

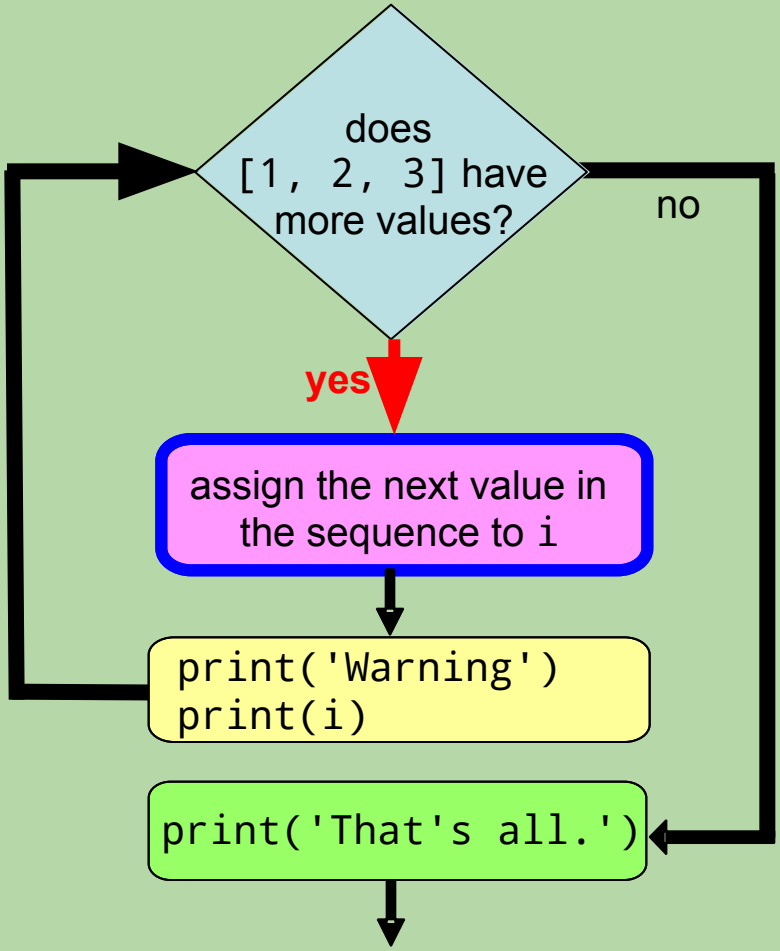
```
for i in [1, 2, 3]:
    print('Warning')
    print(i)
print('That's all.')
```



more?	i	output/action
yes		

Executing Our Earlier Example
(with one extra statement)

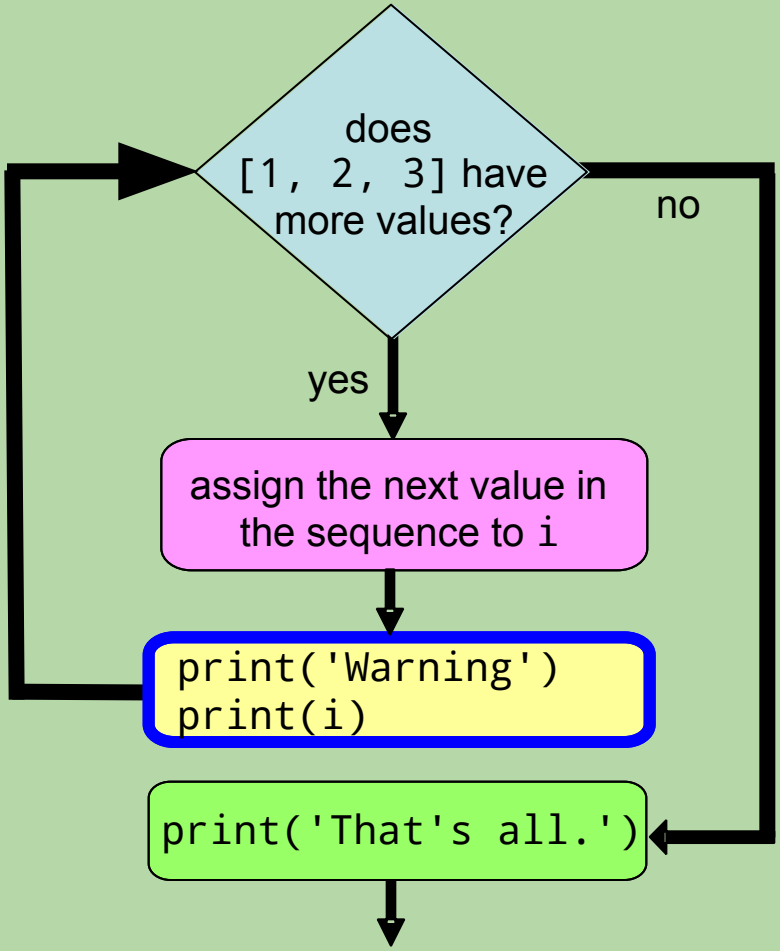
```
for i in [1, 2, 3]:
    print('Warning')
    print(i)
print('That's all.')
```



more?	i	output/action
yes	1	

Executing Our Earlier Example
(with one extra statement)

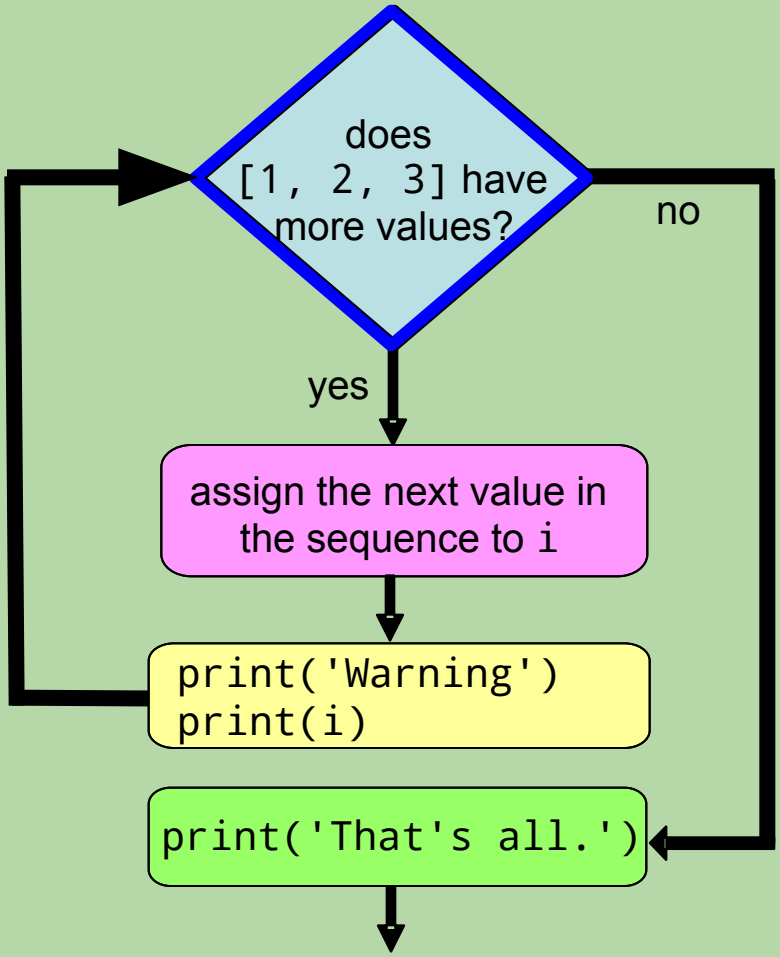
```
for i in [1, 2, 3]:
    print('Warning')
    print(i)
print('That's all.')
```



more?	i	output/action
yes	1	`Warning`
		`1`

Executing Our Earlier Example
(with one extra statement)

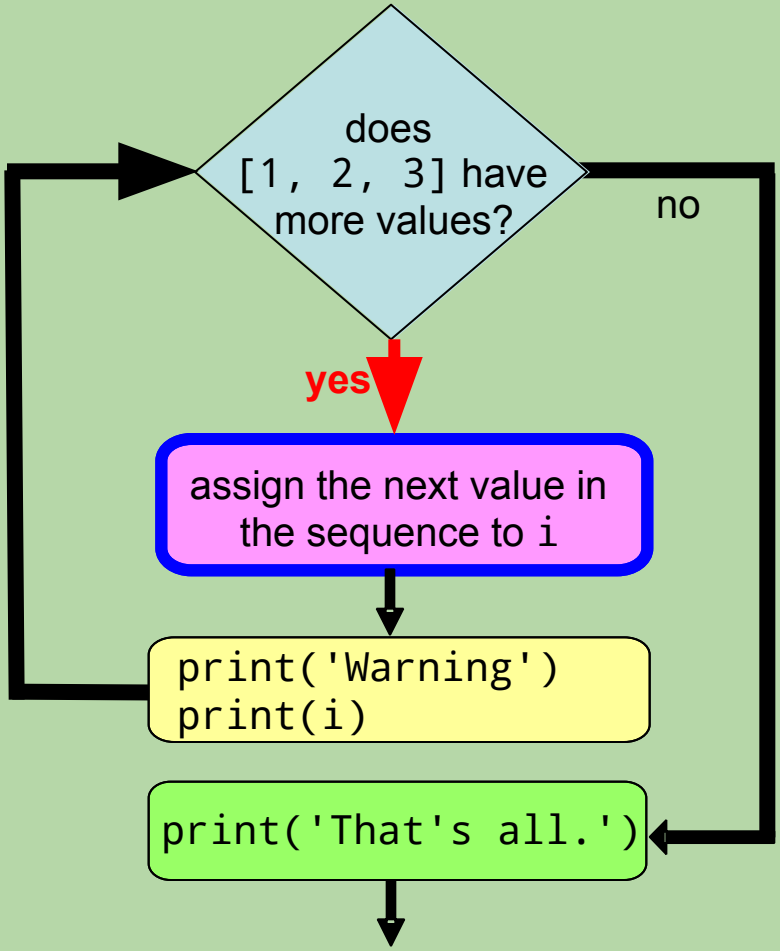
```
for i in [1, 2, 3]:
    print('Warning')
    print(i)
print('That's all.')
```



more?	i	output/action
yes	1	Warning
		1
yes		

Executing Our Earlier Example
(with one extra statement)

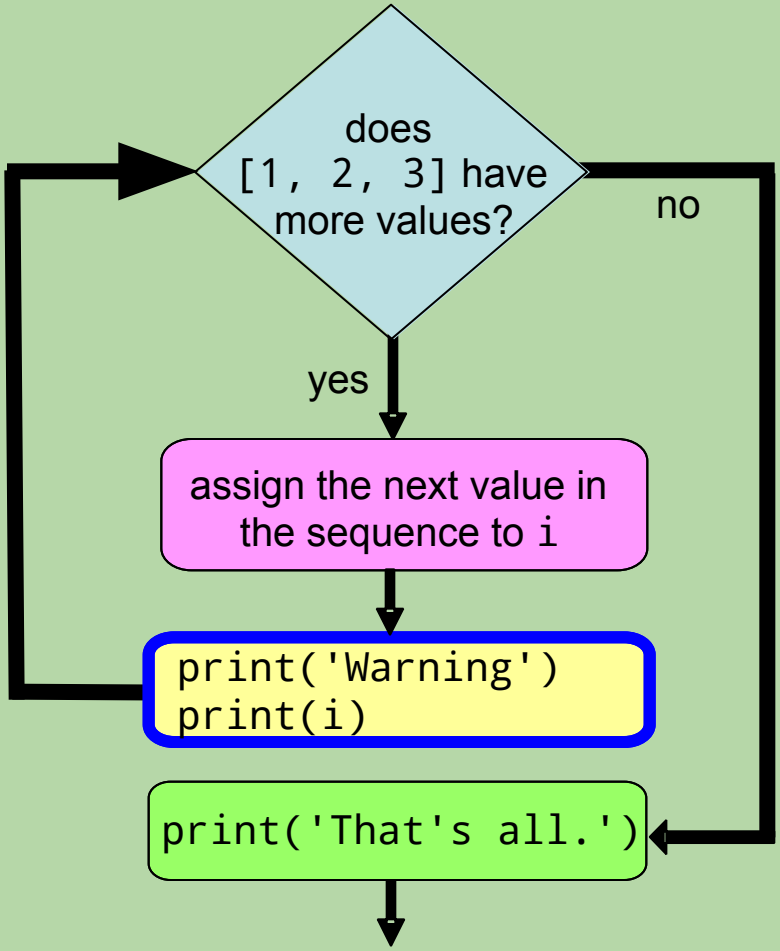
```
for i in [1, 2, 3]:
    print('Warning')
    print(i)
print('That's all.')
```



more?	i	output/action
yes	1	Warning
		1
yes	2	

Executing Our Earlier Example
(with one extra statement)

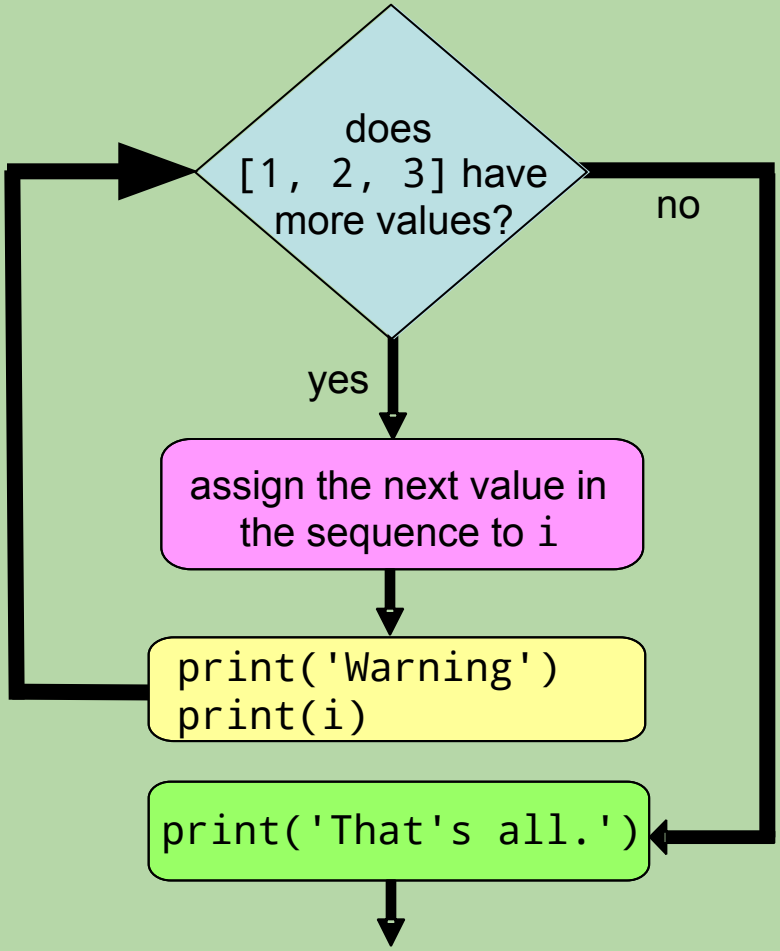
```
for i in [1, 2, 3]:
    print('Warning')
    print(i)
print('That's all.')
```



more?	i	output/action
yes	1	Warning 1
yes	2	Warning 2

Executing Our Earlier Example
(with one extra statement)

```
for i in [1, 2, 3]:
    print('Warning')
    print(i)
print('That's all.')
```

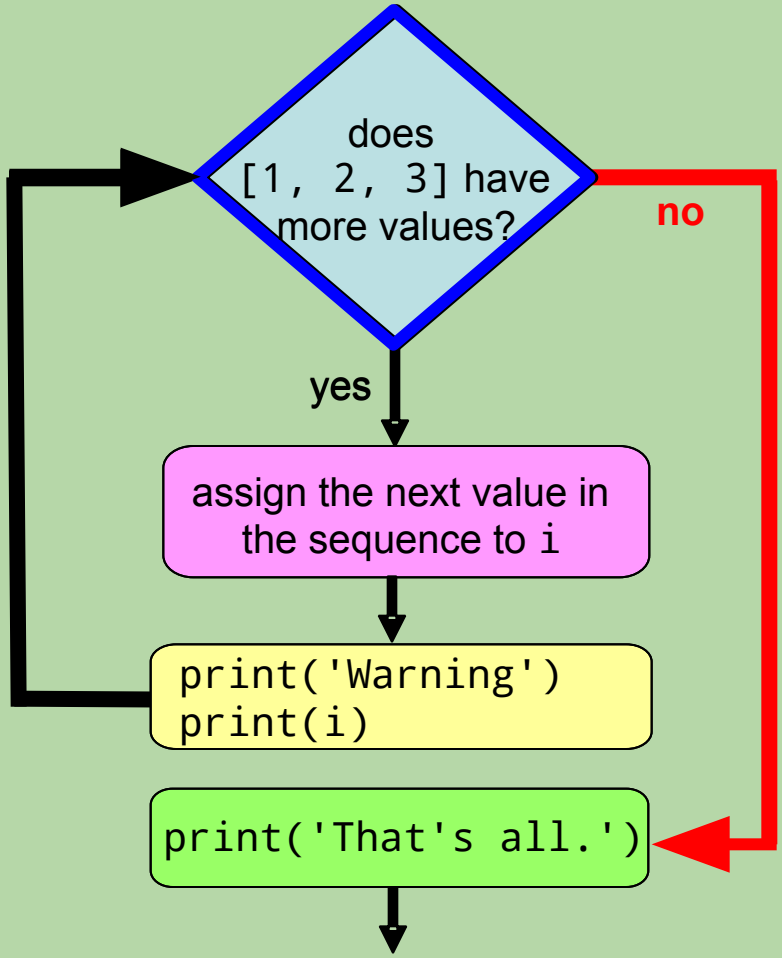


more?	i	output/action
yes	1	Warning 1
yes	2	Warning 2

****skipping to end of loop****

Executing Our Earlier Example
(with one extra statement)

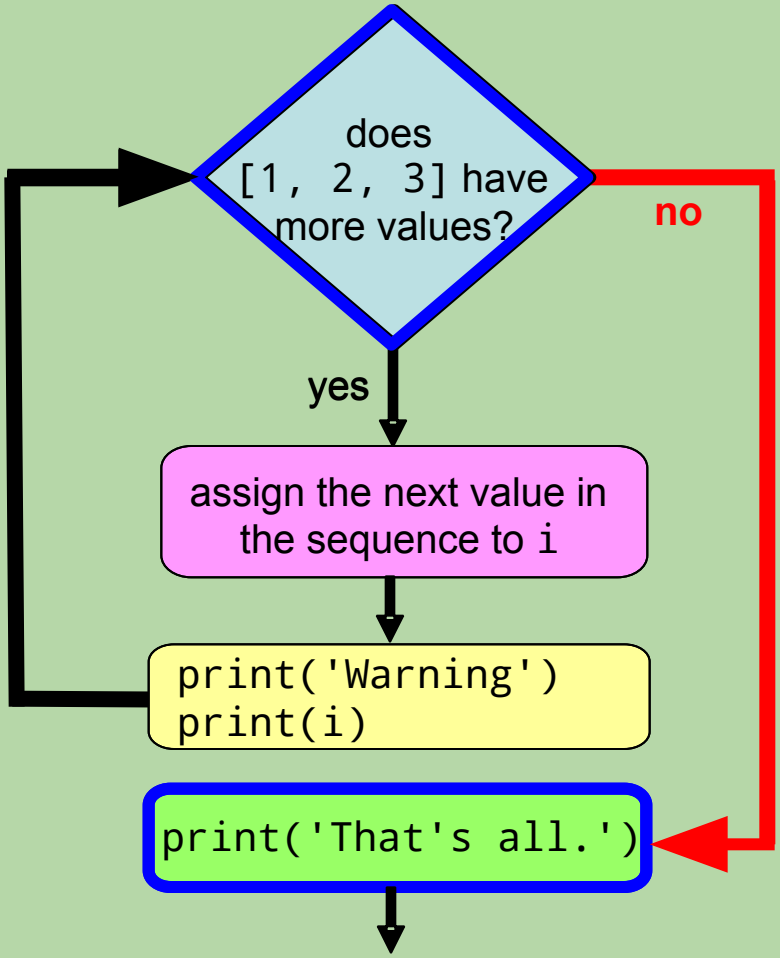
```
for i in [1, 2, 3]:
    print('Warning')
    print(i)
print('That's all.')
```



more?	i	output/action
yes	1	Warning 1
yes	2	Warning 2
yes	3	Warning 3
no		

Executing Our Earlier Example
(with one extra statement)

```
for i in [1, 2, 3]:
    print('Warning')
    print(i)
print('That's all.')
```



more?	i	output/action
yes	1	Warning 1
yes	2	Warning 2
yes	3	Warning 3
no		That's all.

Simple Repetition Loops

- To repeat a loop's body *N* times:

```
for i in range(N):          # [0, 1, 2, ..., N-1]
    <body of the loop>
```

- What would this loop do?

```
for i in range(8):
 print('I'm feeling loopy!')
```

Simple Repetition Loops

- To repeat a loop's body *N* times:

```
for i in range(N):          # [0, 1, 2, ..., N-1]
    <body of the loop>
```

- Example:

```
for i in range(3):          # [0, 1, 2]
    print('I'm feeling loopy!')
```

outputs:

```
I'm feeling loopy!
I'm feeling loopy!
I'm feeling loopy!
```

Simple Repetition Loops

- To repeat a loop's body *N* times:

```
for i in range(N):          # [0, 1, 2, ..., N-1]
    <body of the loop>
```

- Example:

```
for i in range(5):          # [0, 1, 2, 3, 4]
    print('I'm feeling loopy!')
```

outputs:

```
I'm feeling loopy!
I'm feeling loopy!
I'm feeling loopy!
I'm feeling loopy!
I'm feeling loopy!
```

Simple Repetition Loops

- To repeat a loop's body *N* times:

```
for i in range(N):          # [0, 1, 2, ..., N-1]
    <body of the loop>
```

- What would this loop do?

```
for i in range(8):          # [0,1,2,3,4,5,6,7]
    print('I'm feeling loopy!')
```

- Output:

```
I'm feeling loopy!
I'm feeling loopy!
I'm feeling loopy!
I'm feeling loopy!
I'm feeling loopy!
I'm feeling loopy!
I'm feeling loopy!
I'm feeling loopy!
```

8 times!

Simple Repetition Loops (cont.)

- Another example:

```
for i in range(7):
 print(i * 5)
```

How many repetitions?

Output?

Simple Repetition Loops (cont.)

- Another example:

```
for i in range(7): # gives [0, 1, 2, 3, 4, 5, 6]
 print(i * 5)
```

How many repetitions? 7

Output?

```
0
5
10
15
20
25
30
```

`for` Loops Are Definite Loops

- A *definite* loop is a loop in which the number of repetitions is *fixed before the loop even begins*.

- In a `for` loop, # of repetitions = `len(`*sequence*`)`

```
for <variable> in <sequence>:
    <body of the loop>
```

To print the warning 20 times, how could you fill in the blank?

```
for i in ____________________:
    print('Warning!')
```

A. `range(20)`

B. `[1] * 20`

C. `'abcdefghijklmnopqrst'`

D. either A or B would work, but not C

E. A, B or C would work

To print the warning 20 times, how could you fill in the blank?

```
for i in ____________________:
    print('Warning!')
```

A. `range(20)`

B. `[1] * 20`

C. `'abcdefghijklmnopqrst'`

These are all sequences with a length of 20!

D. either A or B would work, but not C

E. A, B or C would work

Python Arithmetic Shortcuts (language feature)

- Here are some ***augmented assignment*** statements that can be used in for loops!

- Consider this code:

```
age = 14
age = age + 1
```

- Instead of writing

```
age = age + 1
```

we can just write

```
age += 1
```

Python Arithmetic Shortcuts (cont.)

shortcut	equivalent to
var += *expr*	*var* = *var* + (*expr*)
var -= *expr*	*var* = *var* – (*expr*)
var *= *expr*	*var* = *var* * (*expr*)
var /= *expr*	*var* = *var* / (*expr*)
var //= *expr*	*var* = *var* // (*expr*)
var %= *expr*	*var* = *var* % (*expr*)
var **= *expr*	*var* = *var* ** (*expr*)

where *var* is a variable
expr is an expression

- **Important:** the = must come *after* the other operator.
  - += is correct
  - =+ is not!

To add the numbers in the list vals, how could you fill in the blanks?

```
def sum(vals):
    result = 0
    for _____________________________:
        result += _____________________
    return result
```

	first blank	second blank
A.	`x in vals`	`x`
B.	`x in vals`	`vals[x]`
C.	`i in range(len(vals))`	`vals[i]`

D. either A or B would work, but not C

E. either A or C would work, but not B

To add the numbers in the list vals, how could you fill in the blanks?

```
def sum(vals):
    result = 0
    for _____________________________:
        result += _____________________
    return result
```

	first blank	second blank
A.	`x in vals`	`x`
B.	`x in vals`	`vals[x]`
C.	`i in range(len(vals))`	`vals[i]`

D. either A or B would work, but not C

E. either A or C would work, but not B

Using a Loop to Sum a List of Numbers

```
def sum(vals):
    result = 0
    for x in vals:
        result += x
    return result

print(sum([10, 20, 30, 40, 50]))
```

Trace the execution of sum, determine the output

x	result

Using a Loop to Sum a List of Numbers

```
def sum(vals):                  # vals = [10, 20, 30, 40, 50]
    result = 0
    for x in vals:
        result += x
    return result                           # returns 150

print(sum([10, 20, 30, 40, 50]))     # print(150)
```

x	result
	0
10	10
20	30
30	60
40	100
50	150

no more values in `vals`, so we're done: **return:** 150, **output:** 150

Using a Loop to Sum a List of Numbers

```
def sum(vals):
    result = 0                  # the accumulator variable
    for x in vals:
        result += x     # gradually accumulates the sum
    return result

print(sum([10, 20, 30, 40, 50]))
```

x	result
	0
10	10
20	30
30	60
40	100
50	150

no more values in `vals`, so we're done: **return:** 150, **output:** 150

Another Example

- What would this code output?

```
num_iters = 0
for val in [2, 4, 16, 8, 10]:
    num_iters += 1
    print(val * 10)
print(num_iters)
```

- Use a table to help you:

more?	val	num_iters	output

Another Example

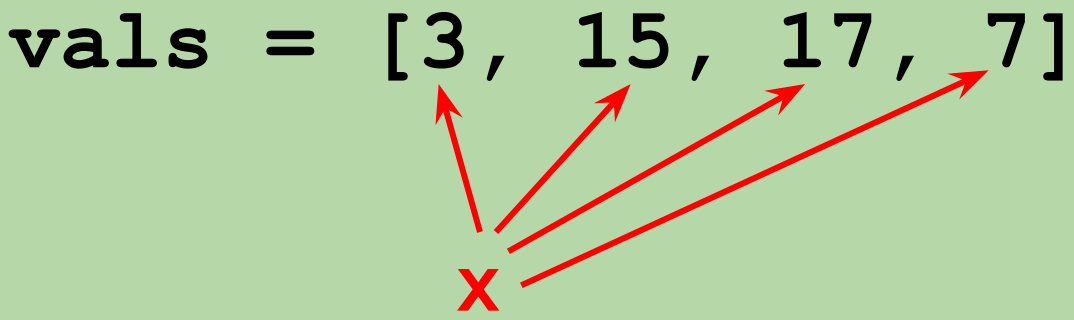
- What would this code output?

```
num_iters = 0
for val in [2, 4, 16, 8, 10]:
    num_iters += 1        # num_iters = num_iters + 1
    print(val * 10)
print(num_iters)
```

- Use a table to help you:

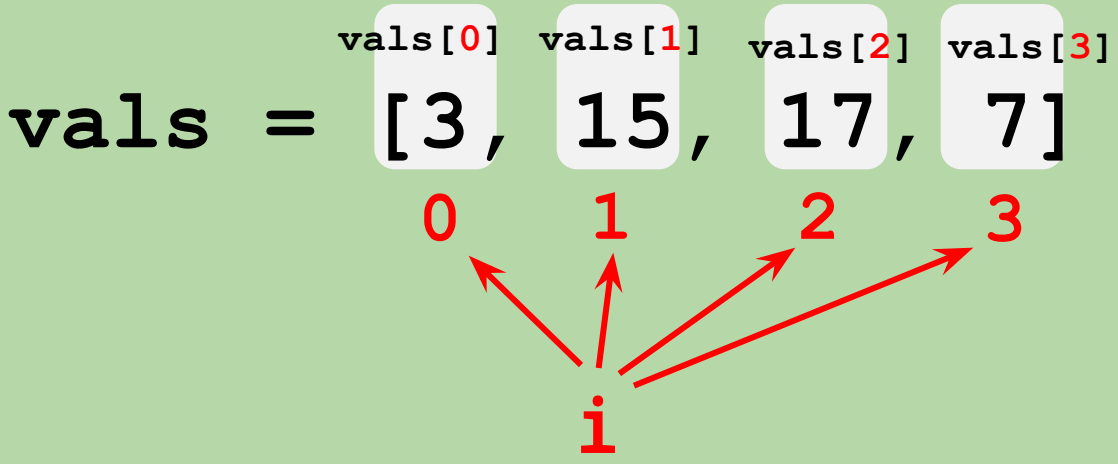
more?	val	num_iters	output
yes	2	1	20
yes	4	2	40
yes	16	3	160
yes	8	4	80
yes	10	5	100
no	10	5	5

Element-Based for Loop




```
def sum(vals):
    result = 0
    for x in vals:
        result += x
    return result
```

Index-Based for Loop




```
def sum(vals):
    result = 0
    for i in range(len(vals)):
        result += vals[i]
    return result
```

Tracing an Index-Based Cumulative Sum

```
def sum(vals):
    result = 0
    for i in range(len(vals)):  →
        result += vals[i]
    return result

print(sum([10, 20, 30, 40, 50]))
```

i	vals[i]	result

Tracing an Index-Based Cumulative Sum

```
def sum(vals):                    # vals = [10, 20, 30, 40, 50]
    result = 0                     # initializer
    for i in range(len(vals)): # range(5) → 0,1,2,3,4
        result += vals[i]
    return result                  # return 150

print(sum([10, 20, 30, 40, 50]))  # print(150)
```

i	vals[i]	result
		0
0	10	10
1	20	30
2	30	60
3	40	100
4	50	150

no more values in `range(5)`, so we're done

return 150, **output: 150**

Tracing an Index-Based Cumulative Sum

```
def sum(vals):
    #result = 0
    for i in range(len(vals)):
        result += vals[i]
    return result

print(sum([10, 20, 30, 40, 50]))
```

What happens if we omit the initializer?

A. Nothing, it works fine
B. Undefined, initialized with random number
C. Error, local variable referenced before initialization
D. Python would look for global variable

Tracing an Index-Based Cumulative Sum

```
def sum(vals):
    #result = 0
    for i in range(len(vals)):
        result += vals[i]
    return result

print(sum([10, 20, 30, 40, 50]))
```

What happens if we omit the initializer?

A. Nothing, it works fine
B. Undefined, initialized with random number
C. Error, local variable referenced before initialization
D. Python would look for global variable

What is the output of this program?

```
def mystery(vals):
    result = 0
    for i in range(len(vals)):
        if vals[i] == vals[i - 1]:
            result += 1
    return result

print(mystery([5, 7, 7, 2, 3, 3, 5]))
```

i	vals[i]	vals[i - 1]	result

A. 0

B. 1

C. 2

D. 3

E. 7

What is the output of this program?

```
def mystery(vals):     # vals = [5, 7, 7, 2, 6, 6, 5]
    result = 0
    for i in range(len(vals)): # range(7) → 0,1,2,3,4,5,6
        if vals[i] == vals[i - 1]:
            result += 1
    return result # return 3

print(mystery([5, 7, 7, 2, 3, 3, 5])) # print 3
```

A. 0

B. 1

C. 2

D. 3

E. 7

i	vals[i]	vals[i - 1]	result
		0	
0	5	5	1
1	7	5	1
2	7	7	2
3	2	7	2
4	6	2	2
5	6	6	3
6	5	6	3

More on Cumulative Arithmetic

- Here's a loop-based factorial in Python:

```
def fac(n):
    result = 1
    for x in range(n)
        result *= x
    return result
```

- Does this function work?

More on Cumulative Arithmetic

- Here's a loop-based factorial in Python:

```
def fac(n):
    result = 1
    for x in range(n)
        result *= x
    return result
```

- Does this function work? **No!**

```
def fac(n):
    result = 1
    for x in range(n) # [0,1,2,…,n-1]
        result *= x   # 1* 0 = 0…
    return result    # result = 0
```

More on Cumulative Arithmetic

- How can we make this do what we want?

```
def fac(n):
    result = 1
    for x in range(__________):  # fill in the
blank
        result *= x
    return result
```

Hint:

```
range([start], stop[, step])

    start: Starting number of the sequence.
    stop: Generate numbers up to, but not including this number.
    step: Difference between each number in the sequence.
```

More on Cumulative Arithmetic

- How can we make this do what we want?

```
def fac(n):
    result = 1
    for x in range(1, n + 1):
        result *= x
    return result
```

Hint:

```
range([start], stop[, step])

    start: Starting number of the sequence.
    stop: Generate numbers up to, but not including this number.
    step: Difference between each number in the sequence.
```

More on Cumulative Arithmetic

- Here's a loop-based factorial in Python:

```
def fac(n):
    result = 1              # the accumulator variable
    for x in range(1, n + 1):
        result *= x         # accumulates the
factorial
    return result
```

- Is this loop element-based or index-based?
  element-based – the loop variable takes on elements from the sequence that we're processing

More on Cumulative Arithmetic

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```
def fac(n):
    result = 1              # the accumulator variable
    for x in range(1, n + 1):
        result *= x         # accumulates the
factorial
    return result
```

- Is this loop element-based or index-based?

Cumulative Arithmetic with Strings

- Let's define an iterative `remove_vowels` function that takes in a string s and returns the string without any vowels:

```
def remove_vowels(s):
        # your code here!
```

- Examples:

```
>>> s = remove_vowels('recurse')
>>> print(s)
'rcrs'
>>> s = remove_vowels('vowels')
>>> print(s)
'vwls'
```

Cumulative Arithmetic with Strings (cont.)

- Here's one loop-based version:

```
def remove_vowels(s):
    result = ''                 # the accumulator
    for c in s:
        if c not in 'aeiou':
            result += c         # accumulates the
result
    print result
```

Cumulative Arithmetic with Strings (cont.)

- Here's one loop-based version:

```
def remove_vowels(s):
    result = ''
    for c in s:
        if c not in 'aeiou':
            result += c
    return result
```

- Let's trace through `remove_vowels('vowels')`:

```
s = 'vowels'
 c        result
```

Cumulative Arithmetic with Strings (cont.)

- Here's one loop-based version:

```
def remove_vowels(s):
    result = ''
    for c in s:
        if c not in 'aeiou':
            result += c
    return result
```

- Let's trace through `remove_vowels('vowels')`:

```
s = 'vowels'
```

c	result
	''
'v'	'' + 'v' → 'v'
'o'	'v' (no change)
'w'	'v' + 'w' → 'vw'
'e'	'vw' (no change)
'l'	'vw' + 'l' → 'vwl'
's'	'vwl' + 's' → **'vwls'**

List Comprehensions

- List comprehensions use **for** loops within brackets to construct a list
- We can create a list of integers up to i by using list comprehensions

```
def create_list(size):
    result = [i for i in range(size)]
    return result

def squares(length):
    return [x**2 for x in range(length)]
```

- Format: [*expression for item in list*]
- The above syntax is useful for creating lists in one line. It includes all items in that list.
- You can also use list comprehensions to modify an existing list.

Why not just use '`result = range(size)`'?

List Comprehensions (cont.)

- We can include if-else statements to perform more complex operations.
- Let's try the remove vowel function with list comprehensions.

```
def remove_vowels(str):
    result = [c for c in str if c not in 'aeiou']
    return result
```

- This syntax allows us to use complex expressions to make a list in a single line.

- 2 valid formats:

  [*expression1 if condition else expression2 for item in list*]

  [*expression for item in list if condition*]

What is the output of the following expression?

```
def double_evens(int_list):
    return [2*i if i%2==0 else i for i in int_list]

double_evens([i for i in range(10)]
```

A. [0,1,4,3,8,5,12,7,16,9]
B. [0,1,2,3,4,5,6,7,8,9]
C. [0,1,4,3,4,5,12,7,16,9,20]
D. [0,4,8,12,16]
E. Error message

What is the output of the following expression?

```
def double_evens(int_list):
    return [2*i if i%2==0 else i for i in int_list]

double_evens([i for i in range(10)])
```

A. [0,1,4,3,8,5,12,7,16,9]
B. [0,1,2,3,4,5,6,7,8,9]
C. [0,1,4,3,4,5,12,7,16,9,20]
D. [0,4,8,12,16]
E. Error message

What does this program output?

```
s = 'time to think! '
result = ''
for i in range(len(s)):
    if s[i - 1] == ' ':
        result += s[i]
print(result)
```

i	s[i-1]s[i]	result

A. tt

B. ttt

C. tothink!

D. timetothink!

E. none of these

What does this program output?

```
s = 'time to think! '
result = ''
for i in range(len(s)):
    if s[i - 1] == ' ':
        result += s[i]
print(result)
```

A. tt

B. **ttt**

C. tothink!

D. timetothink!

E. none of these

i	s[i-1]s[i]	result
		''
0	' ' 't'	**'t'**
1	't' 'i'	't'
2	'i' 'm'	't'
3	'm' 'e'	't'
4	'e' ' '	't'
5	' ' 't'	**'tt'**
6	't' 'o'	'tt'
7	'o' ' '	'tt'
8	' ' 't'	**'ttt'**
9	't' 'h'	'ttt'
10	'h' 'i'	'ttt'
11	'i' 'n'	'ttt'
12	'n' 'k'	'ttt'
13	'k' '!'	'ttt'
14	'!' ' '	'ttt'

What does this program output?

```
s = 'time to think! '
result = ''
for i in range(len(s)):
    if s[i - 1] == ' ':
        result += s[i]
print(result)
```

Could you do the same thing using an *element*-based `for` loop?

```
s = 'time to think! '
result = ''
for c in s:
    if ________ == ' ':
        result += _____
print(result)
```

i	s[i-1]s[i]	result
		''
0	' ' 't'	't'
1	't' 'i'	't'
2	'i' 'm'	't'
3	'm' 'e'	't'
4	'e' ' '	't'
5	' ' 't'	'tt'
6	't' 'o'	'tt'
7	'o' ' '	'tt'
8	' ' 't'	'ttt'
9	't' 'h'	'ttt'
10	'h' 'i'	'ttt'
11	'i' 'n'	'ttt'
12	'n' 'k'	'ttt'
13	'k' '!'	'ttt'
14	'!' ' '	'ttt'

What does this program output?

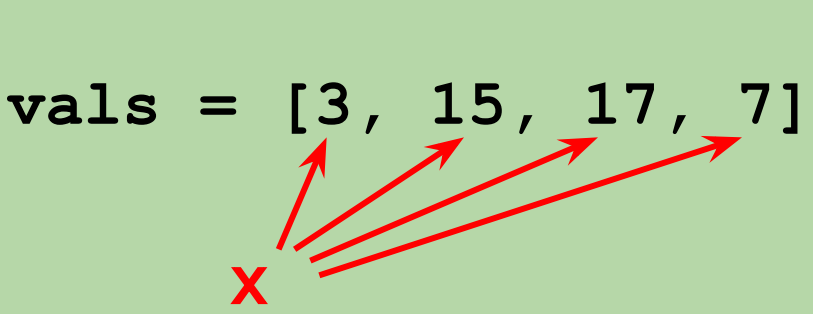
```
s = 'time to think! '
result = ''
for i in range(len(s)):
    if s[i - 1] == ' ':
        result += s[i]
print(result)
```

Could you do the same thing using an *element*-based `for` loop? ***no***

```
s = 'time to think! '
result = ''
for c in s:
    if ???? == ' ':
        result += c
print(result)
```

i	s[i-1]s[i]	result
		''
0	' ' 't'	't'
1	't' 'i'	't'
2	'i' 'm'	't'
3	'm' 'e'	't'
4	'e' ' '	't'
5	' ' 't'	'tt'
6	't' 'o'	'tt'
7	'o' ' '	'tt'
8	' ' 't'	'ttt'
9	't' 'h'	'ttt'
10	'h' 'i'	'ttt'
11	'i' 'n'	'ttt'
12	'n' 'k'	'ttt'
13	'k' '!'	'ttt'
14	'!' ' '	'ttt'

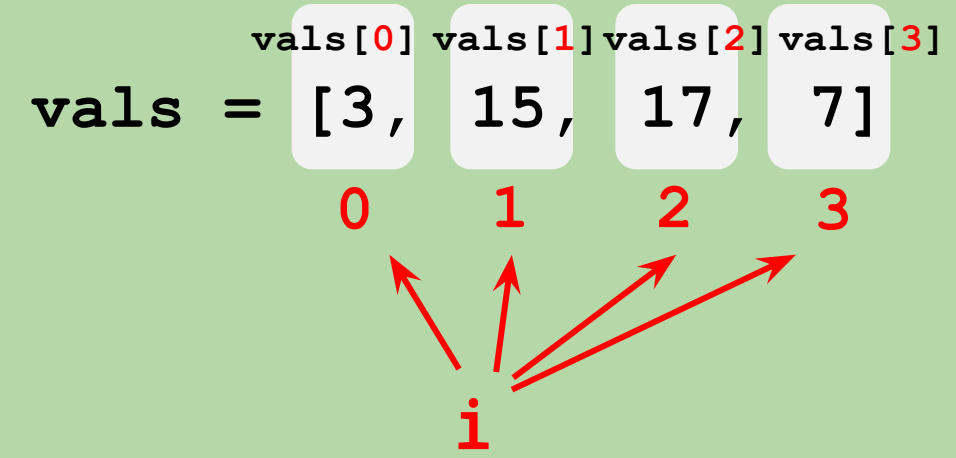
Simpler




```
def sum(vals):
    result = 0
    for x in vals:
        result += x
    return result
```

element-based loop

More Flexible




```
def sum(vals):
    result = 0
    for i in range(len(vals)):
        result += vals[i]
    return result
```

index-based loop

Stretch Break!

Meet UTA Alex Liu's Nephew Wesley. When Wesley rests, we all rest

Side Note: Staying on the Same Line When Printing

- By default, `print` puts an invisible *newline* character at the end of whatever it prints.
  - causes separate `print`s to print on different lines

- Example: What does this output?

```
for i in range(7):
    print(i * 5)
```

Side Note: Staying on the Same Line When Printing

- By default, `print` puts an invisible *newline* character at the end of whatever it prints.
  - causes separate `print`s to print on different lines

- Example: What does this output?

```
for i in range(7):
    print(i * 5)
```

```
0
5
10
15
20
25
30
```

Staying on the Same Line When Printing (cont.)

- To get separate `prints` to print on the same line, we can replace the newline with something else.

- Examples:

```
for i in range(7):
    print(i * 5, end=' ')
```

```
0 5 10 15 20 25 30
```

```
for i in range(7):
    print(i * 5, end=',')
```

```
0,5,10,15,20,25,30,
```