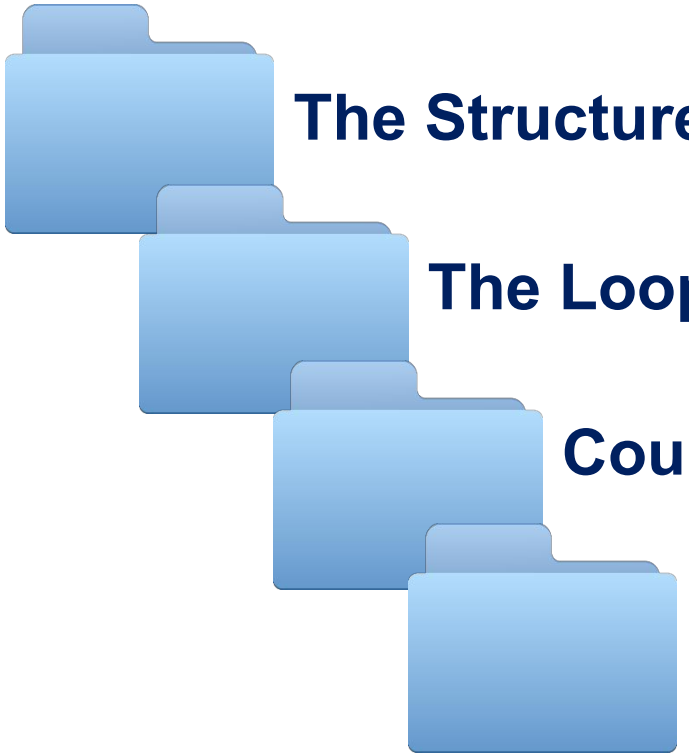
Basic Program Structure
Repetition (Looping)

Lesson Objectives

At the end of this lesson, you should be able to:

- Explain the need for repetition in programming
- Familiarize with the structure of a loop
- Apply the loop design strategy when developing loops
- Distinguish between counter-controlled loop and sentinel-controlled loop

Topic Outline



The Structure of a Loop

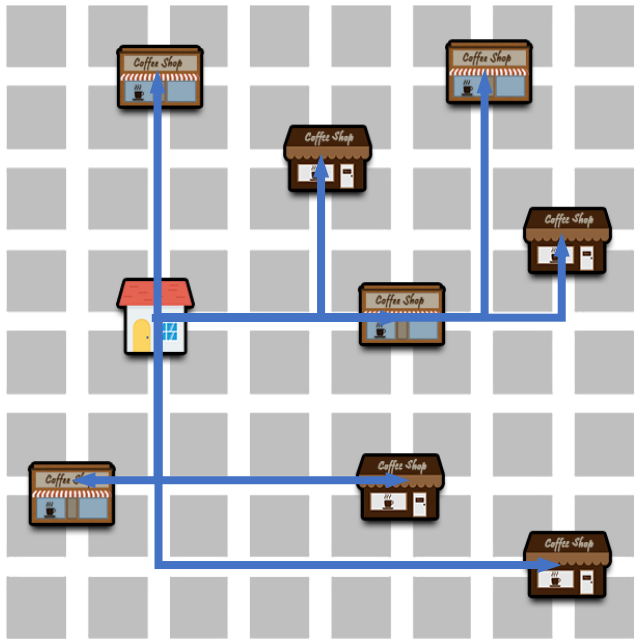
The Loop Design Strategy

Counter-Controlled Loop

Sentinel-Controlled Loop

Recall: Finding Distance Between Two Points

What if there were many coffee shops?



If we only have a *sequence*… ⇒ Tedious

We need to **repeat certain instruction(s).**

E.g., calculate the travel distance between two points **exactly *N* times**, where ***N*** is the total number of coffee shops.

***N* times**

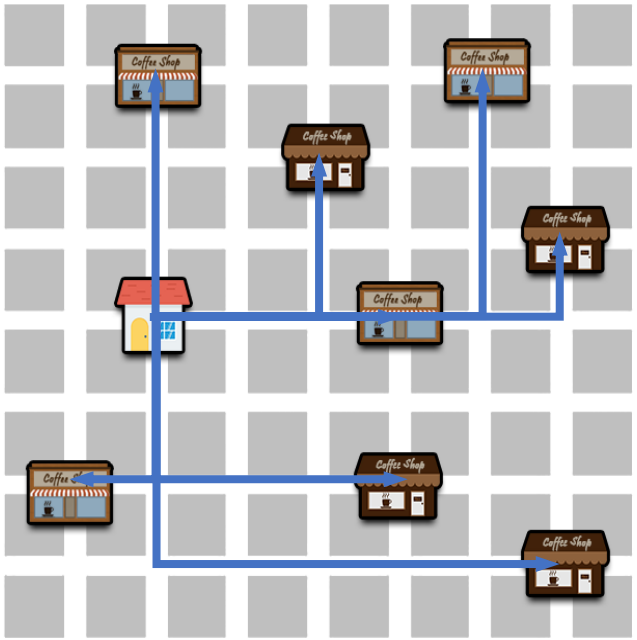
```
Read horizonDist
Read vertDist
dist = horizonDist + vertDist
Display distance traveled between these two points
```

```
Read horizonDist
Read vertDist
dist = horizonDist + vertDist
Display distance traveled between these two points
```

```
⋮
```

Recall: Finding Distance Between Two Points

What if there were many coffee shops?



If we only have a *sequence*…

⇒ **Not reusable**

Example

Different users have different numbers of coffee shops nearby.

Hence, the number to repeat the certain instruction has to be changed for different users.

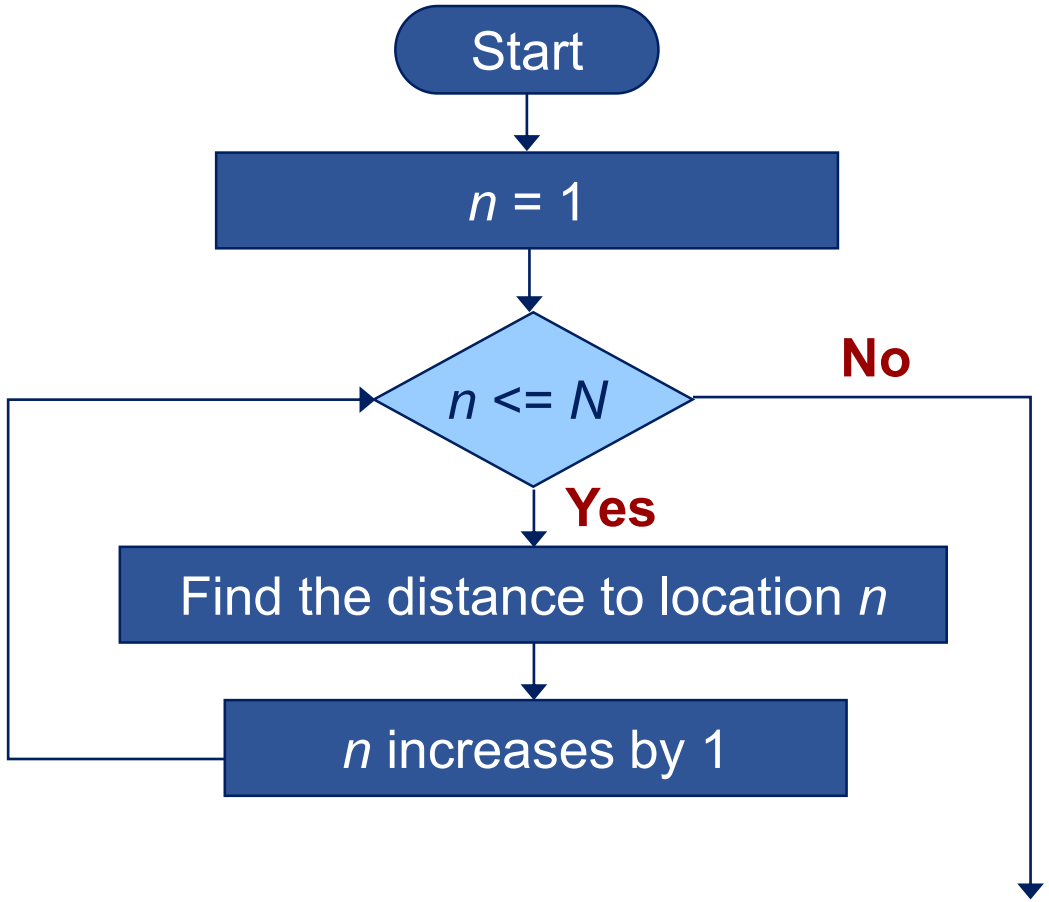
Solution: Looping

Looping

A computer program **can dynamically** choose how many times it repeats certain instruction(s) during the programme runtime.

Program instructions can be repeated dynamically.

- Sometimes three times, sometimes 1,000 times, or sometimes not even repeat at all.



Solution: Looping (Cont'd)

The program is the same for different users (it doesn't need to change for different numbers of repetitions).

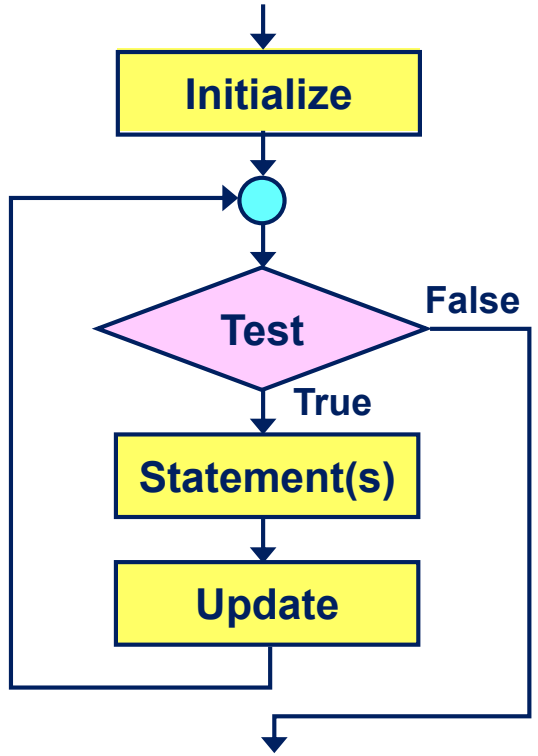
Pseudocode

```
Count = 1
WHILE count <= N
      Read horizonDist
      Read vertDist
      dist = horizonDist + vertDist
      Display distance traveled between two points
      Increase count by 1
END WHILE
```

General Structure of a Loop

Four Steps

1. **Initialize** Loop control variable
2. **Test** Continue the loop or not?
3. **Loop body** Main computation being repeated
4. **Update** Modify the value of the loop control variable so that next time when we test, we may exit the loop



- Sometimes a loop may not have all of them. E.g., *Infinite loop* (Test condition is always true).
- A one-time execution of a loop body is referred to as an **iteration** of the loop.

General Structure of a Loop: More Application

Compute the Average Height of the Students in a Class

General Structure of a Loop: More Application (Cont'd)

Compute the Average Height of N Students in a Class

Pseudocode

```
SET sum TO 0
1  SET counter TO 0                    // Initialize
2  WHILE counter < N                   // Test
3      READ height                     // Loop body
       ADD height TO sum
4      INCREMENT counter BY 1          // Update
END WHILE
COMPUTE average = sum / counter
PRINT average
```

Loop Design Strategies

Step 1

Identify the statements that need to be repeated

Step 2

Wrap these statements in a loop

```
while (true) {
Statements;
}
```

Step 3

Code the loop-continuation-condition and add appropriate statements for controlling loop

```
while (loop-continuation-condition) {
    Statements;
    Additional statements for controlling the loop;
}
```

Note: In designing loops, consider both the loop control structure and the loop body.

Two Kinds of Loops

Counter-Controlled Loop

The number of repetitions can be **known** before the loop body starts; just repeat the loop on each element in a preset sequence.

Sentinel-Controlled Loop

The number of repetitions is **NOT known** before the loop body starts.

- For example, a *sentinel value* (e.g. –1, different from normal data).

Counter-Controlled Loop: Application

Compute the Average Height of the Students in a Class

Pseudocode

```
sum = 0.0
REPEAT N times
  ASK user for next student's height
  sum += height
END of REPEAT
Average = sum / N
```

Assumption: The number of students is known before the start of the loop

Sentinel-Controlled Loop: Application

Compute the Average Height of the People Entering Canteen A in a Day

Are we able to know **beforehand** the number of people entering Canteen A before we start the loop body?

NO

Sentinel-Controlled Loop: Application (Cont'd)

Compute the Average Height of the People Entering Canteen A in a Day

A sentinel value is a special value that signifies the end of the loop.

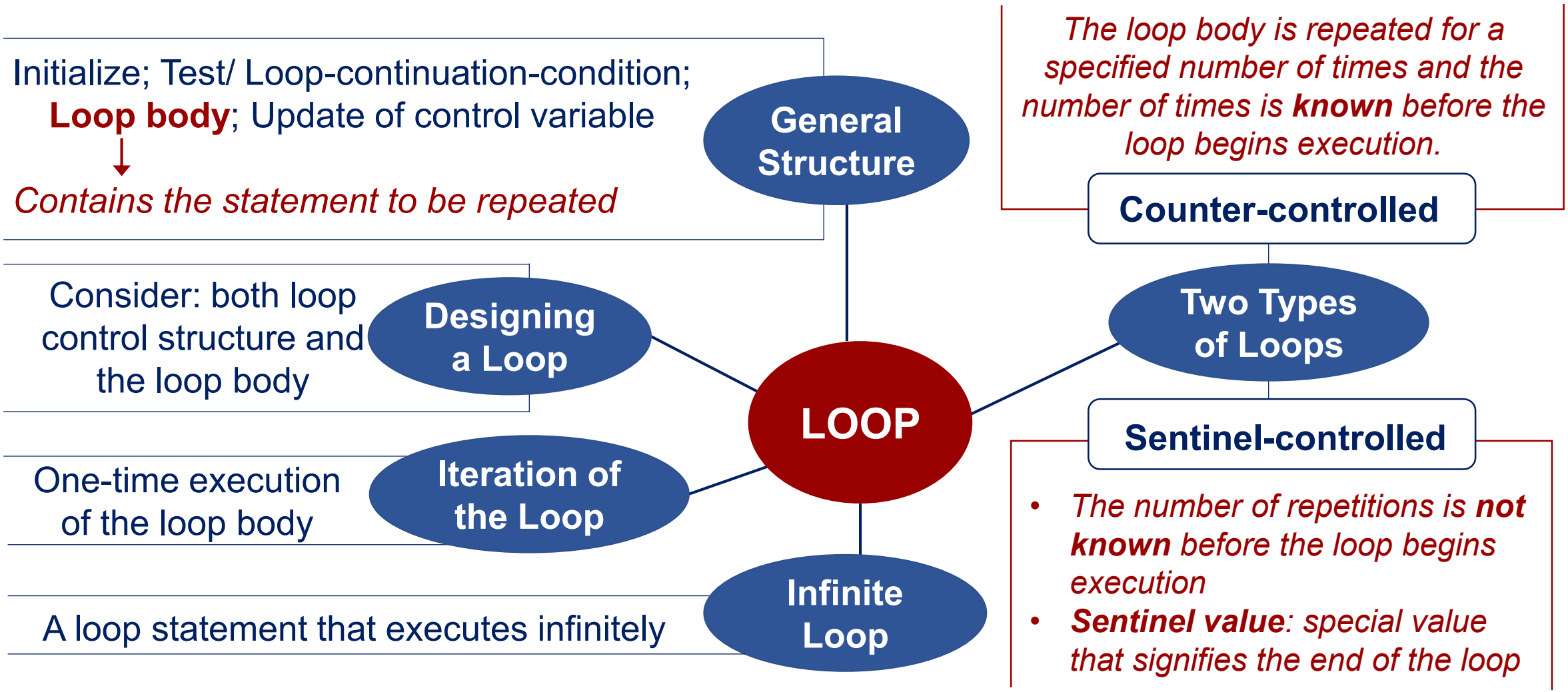
Note: **Time** is the loop control variable.

Pseudocode

```
sum = count = 0                          Initialize
time = get current time
WHILE time < Canteen A closing time      Test
    height = get height of next guy      Loop body
    sum += height
    count += 1
    time = get current time              Update
END WHILE
```

Loop-continuation-condition: *time is earlier than closing time*.

Summary


Initialize; Test/ Loop-continuation-condition;
Loop body; Update of control variable
Contains the statement to be repeated
General Structure
The loop body is repeated for a specified number of times and the number of times is known before the loop begins execution.
Counter-controlled
Consider: both loop control structure and the loop body
Designing a Loop
Two Types of Loops
LOOP
Sentinel-controlled
One-time execution of the loop body
Iteration of the Loop
The number of repetitions is not known before the loop begins execution
Sentinel value: special value that signifies the end of the loop
Infinite Loop
A loop statement that executes infinitely

References for Images

No.	Slide No.	Image	Reference
1	6		Survey icon [Online Image]. Retrieved April 18, 2018 from https://pixabay.com/en/survey-icon-survey-icon-2316468/.
2	13		By Arlington National Cemetery - Medal of Honor Day Bus Tour - loading bus, Public Domain, retrieved June 7, 2018 from https://commons.wikimedia.org/w/index.php?curid=63839066.
3	13		Alpha (2007). Queueing for Tian Tian Hainanese Chicken Rice-Maxwell Road Hawker Center [Online Image]. Retrieved June 16, 2018 from https://www.flickr.com/photos/avlxyz/2498427281.
4	15		Question problem [Online Image]. Retrieved April 18, 2018 from https://pixabay.com/en/question-problem-think-thinking-622164/.

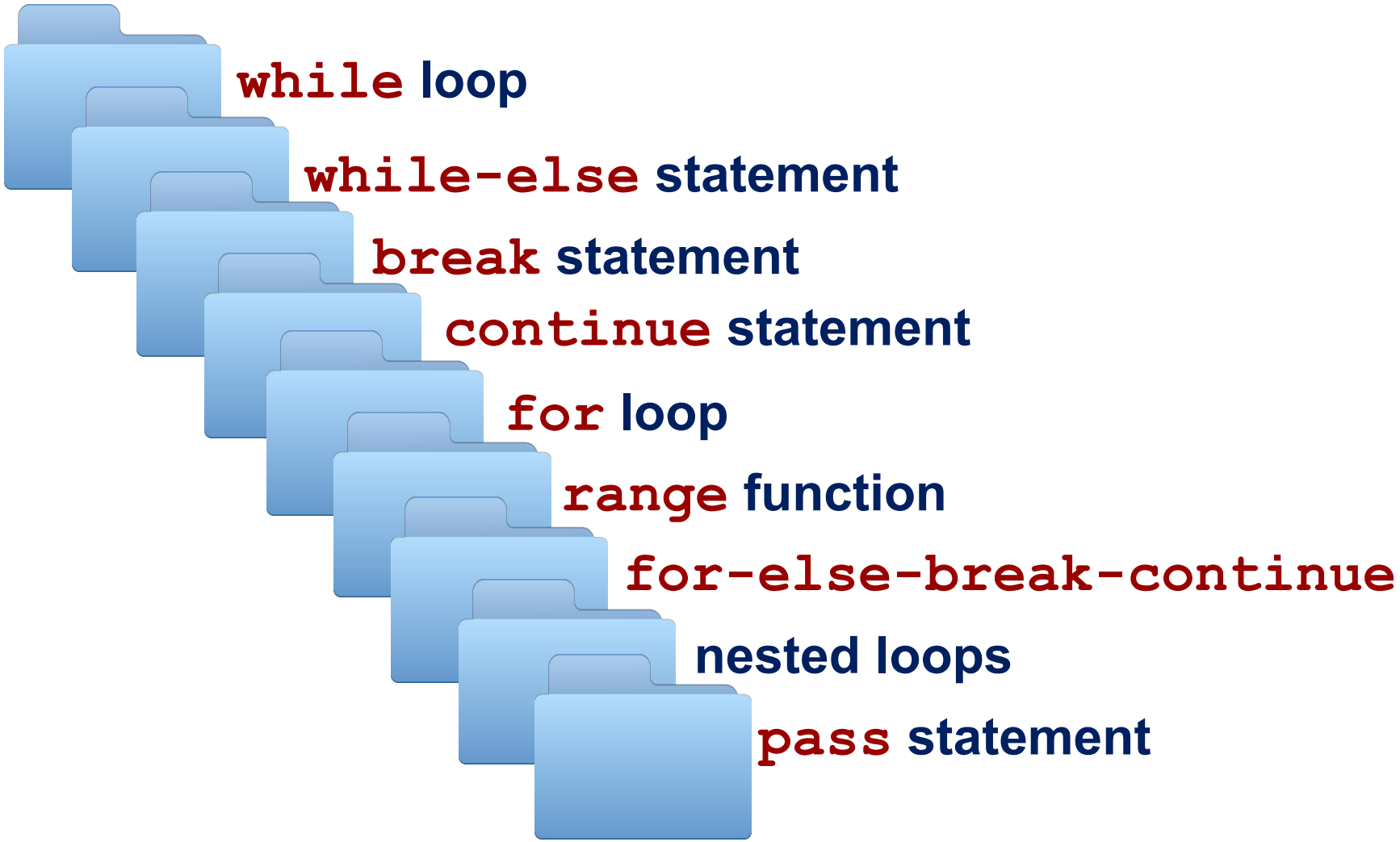
Basic Program Structure
Repetition (Looping) in Python

Lesson Objectives

At the end of this lesson, you should be able to:

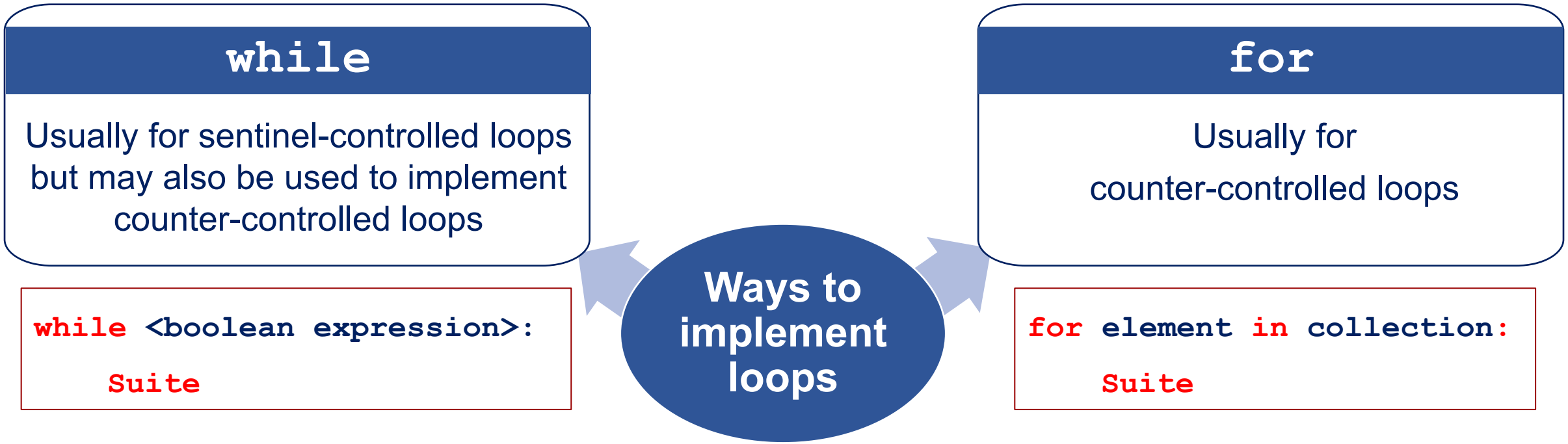
- Write programs for executing statements repeatedly using a ***while*** loop in Python
- Describe how to control a loop with sentinel value in Python
- Write loops using ***for*** statements in Python
- Discuss how to generate a sequence of numbers using the ***range()*** function
- Apply ***for*** loop to iterate through a ***range*** sequence
- Write nested loops in Python
- Implement program control with ***break***, ***pass***, and ***continue*** in Python

Topic Outline



- `while` loop
- `while-else` statement
- `break` statement
- `continue` statement
- `for` loop
- `range` function
- `for-else-break-continue`
- nested loops
- `pass` statement

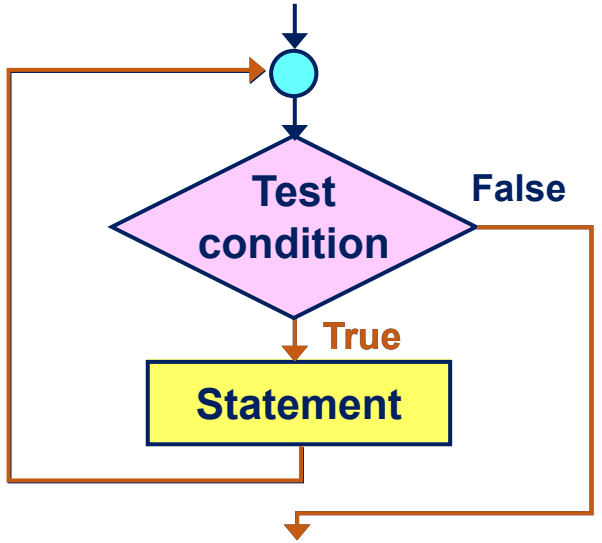
Loops in Python



Loops in Python: `while`

- The **`while`** statement allows repetition a suite of Python codes as long as a condition (Boolean expression) is True.
- It is structurally similar to an **`if`** statement but repeats the block until the condition becomes False.

```
while <boolean expression>:
    Suite (one or more indented statements)
```



- When the condition becomes False, repetition ends and control moves on to the code following the repetition.

Loops in Python: `while` - Syntax

The whole **While** structure

```
while <boolean expression>:
    Suite (one or more indented statements)
```

indentation

It must use a **colon** followed by a proper **indentation**

Loops in Python: `while` - Syntax (Cont'd)

Example

```
# simple while

x = 0 # initialize #loop-control variable

# test loop-control variable at beginning of loop
while x < 10:
    print(x) # print the value of x int each time through the while loop

print()
print("Final value of x int: ", x) # bigger than value printed in loop
```

The whole `while` structure

Output:

```
0
1
2
3
4
5
6
7
8
9

Final value of x int: 10
```

Loops in Python: `while` - Syntax (Cont'd)

More on `print()`

```
x = 0
while x < 10:
  print(x, end =' ')
  x = x + 1
print()
print("Final value of x int: ", x)
```

Output:

```
0 1 2 3 4 5 6 7 8 9
Final value of x int: 10
```

Separate the numbers using @?

```
print(x, end ='@')
```

- The `end =' '` in the print statement indicates that the print ends with an empty string rather than the default new line.
- This means that the output from multiple calls to print will occur on the same output line.

Output

```
0@1@2@3@4@5@6@7@8@9
Final value of x int: 10
```

Quick Check

What is the output of the following code?

```
count = 5
while count < 9:
  count = count + 1
print("count= ", count, end=" ")
```

Quick Check: Answer

What is the output of the following code?

```
count = 5
while count < 9:
  count = count + 1
print("count= ", count, end=" ")
```

Answer count = 9

Quick Check

What is the output of the following code?

```
count = 0
number = 9

while number > 0:
    if number % 2 == 0:
        number //=2
    elif number % 3 ==0:
        number //=3
    else:
        number -=1
    count = count + 1

print ('count is:', count, 'number is:', number)
```

Quick Check: Answer

What is the output of the following code?

```
count = 0
number = 9

while number > 0:
    if number % 2 == 0:
        number //=2
    elif number % 3 ==0:
        number //=3
    else:
        number -=1
    count = count + 1

print ('count is:', count, 'number is:', number)
```

Answer

count is: 3 number is: 0

Quick Check

If line 1 and line 2 were removed, what effect would that have on the program?

```
count = 0
number = 9

while number > 0:
    if number % 2 == 0:
        number //=2
    elif number % 3 ==0:
        number //=3
    else:                       #line 1
        number -=1              #line 2
    count = count + 1

print ('count is:', count, 'number is:', number)
```

Quick Check: Answer

If line 1 and line 2 were removed, what effect would that have on the program?

```
count = 0
number = 9

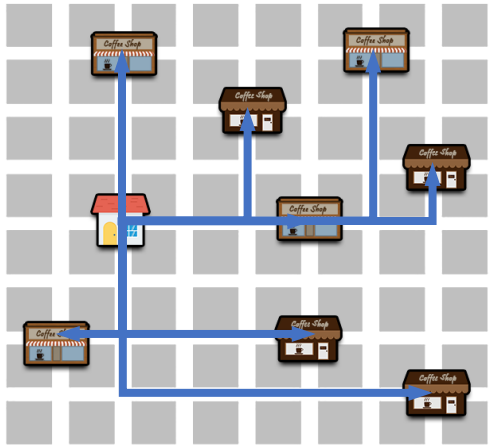
while number > 0:
    if number % 2 == 0:
        number //=2
    elif number % 3 ==0:
        number //=3

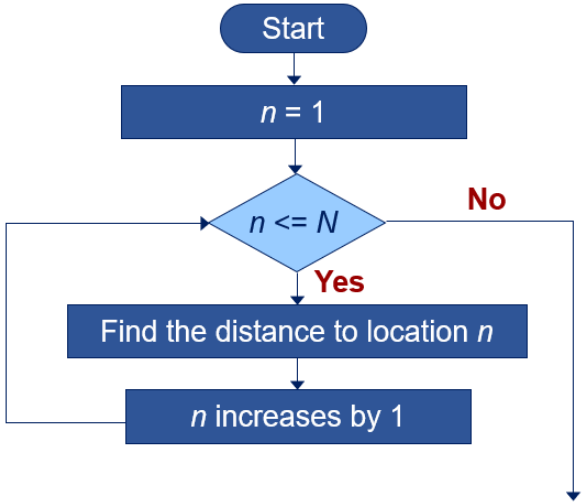

    count = count + 1
print ('count is:', count, 'number is:', number)
```

Answer

The `while` loop will not end.

Application of Looping: Find the Distance to N Locations





Recall

Pseudocode

```
Count = 0
WHILE count < N
        Read horizonDist
        Read vertDist
        dist = horizonDist + vertDist
        Display distance traveled between two points
        Increase count by 1
END WHILE
```

Find the Distance to N Locations: Loop Design Strategies

Step 1 Identify the statements that need to be repeated

```
horizonDist = int(input("Read horizonDist in meters"))
vertDist = int(input("Read vertDist in meters"))
dist = horizonDist + vertDist
print("dist from home to coffee shop ", count, " is ", dist, "m")
```

Find the Distance to N Locations: Loop Design Strategies

(Cont'd)

Step 2 Wrap these statements in a loop

```
while (true) {
Statements;
}
```

```
while True:
    horizonDist = int(input("Read horizonDist in meters"))
    vertDist = int(input("Read vertDist in meters"))
    dist = horizonDist + vertDist
    print("dist from home to coffee shop ", count, " is ", dist, "m")
```

colon

indentation

Find the Distance to N Locations: Loop Design Strategies

(Cont'd)

Step 3 Code the loop-continuation-condition and add appropriate statements for controlling loop

User-friendly message indicating index of current input/ loop control variable

```
N = int(input("How many coffee shops?"))
count = 1
while count <= N:
    print ("input information of coffee shop ", count)
    horizonDist = int(input("Read horizonDist in meters"))
    vertDist = int(input("Read vertDist in meters"))
    dist = horizonDist + vertDist
    print("dist from home to coffee shop ", count, " is ", dist, "m")
    count = count + 1
```

Initialize the loop control variable

Loop-continuation-condition

Update

Find the Distance to N Locations: Check Loop Iteration

```
N = int(input("How many coffee shops?"))
count = 1
while count <= N:
    print ("input information of coffee shop ", count)
    horizonDist = int(input("Read horizonDist in meters"))
    vertDist = int(input("Read vertDist in meters"))
    dist = horizonDist + vertDist
    print("dist from home to coffee shop ", count, " is ", dist, "m")
    count = count + 1
print ("Thank you for using the application")
```

In the loop:

- What is the loop control variable? ➡ **count**
- Counter-controlled or sentinel-controlled?

Check Loop Iteration: Table (N = 2)

Count	Count <= N	Output
1	True	Dist to shop 1
2	True	Dist to shop 2
3	False	

Outputs of Sample Runs

Output Program instructions: 2 times)

How many coffee shops? 2
input information of coffee shop 1
Read horizonDist in meters 332
Read vertDist in meters 432
dist from home to coffee shop 1 is 764 m
input information of coffee shop 2
Read horizonDist in meters 123
Read vertDist in meters 256
dist from home to coffee shop 2 is 379 m
Thank you for using the application

Output (Program instructions: 1 time)

How many coffee shops? 1
input information of coffee shop 1
Read horizonDist in meters 55
Read vertDist in meters 778
dist from home to coffee shop 1 is 833 m
Thank you for using the application

Output (Program instructions: 0 time)

How many coffee shops? -2
Thank you for using the application

Potential Issues in the Program

```
N = int(input("How many coffee shops?"))
count = 1
while count <= N:
    print ("input information of coffee shop ", count)
    horizonDist = int(input("Read horizonDist in meters"))
    vertDist = int(input("Read vertDist in meters"))
    dist = horizonDist + vertDist
    print("dist from home to coffee shop ", count, " is ", dist, "m")
    count = count + 1
print ("Thank you for using the application")
```

How many coffee shops? -2
Thank you for using the application

Something to think about:

- Any potential issues in the program?
- If the user enters a value smaller than 1, what would happen?
- How about if the user enters '9999999999'?

Potential Issues in the Program: Solution

Force the user to input again if the input is out of a reasonable range.

Keep asking until the user enters a number that is at least 1 and at most a certain reasonable limit.

Add a `while` loop

Implementation of the Solution (New While Loop)

New **while**

```
N = int(input("How many coffee shops?"))
while (N < 1 or N > 10):
    print("warning: input value should range from 1 to 10");
    N = int(input ("How many coffee shops?"))
count = 1
while count <= N:
    print ("input information of coffee shop ", count)
    horizonDist = int(input("Read horizonDist in meters"))
    vertDist = int(input("Read vertDist in meters"))
    dist = horizonDist + vertDist
    print("dist from home to coffee shop ", count, " is ", dist, "m")
    count = count + 1
print ("Thank you for using the application")
```

() is okay but redundant

In the loop:

- What is the loop control variable? → **N**
- Counter-controlled or sentinel-controlled?

while loop is useful for the purpose of **repeatedly** asking the user for an input until the input fulfills the requirement

Another Example of Sentinel-Controlled Loop

Write a program to read numbers from a user; sum them up until the input is -1.

```
====================
>>>
Enter value: 2
Enter value: 1.2
Enter value: 4
Enter value: 10
Enter value: -1
total= 17.2
>>>
```

Indicates the end

Note: -1 is called a sentinel value.

Common Sentinel Loop Implementation

```
value = some value
while value != sentinel value:
    # process value
    # get another value
```

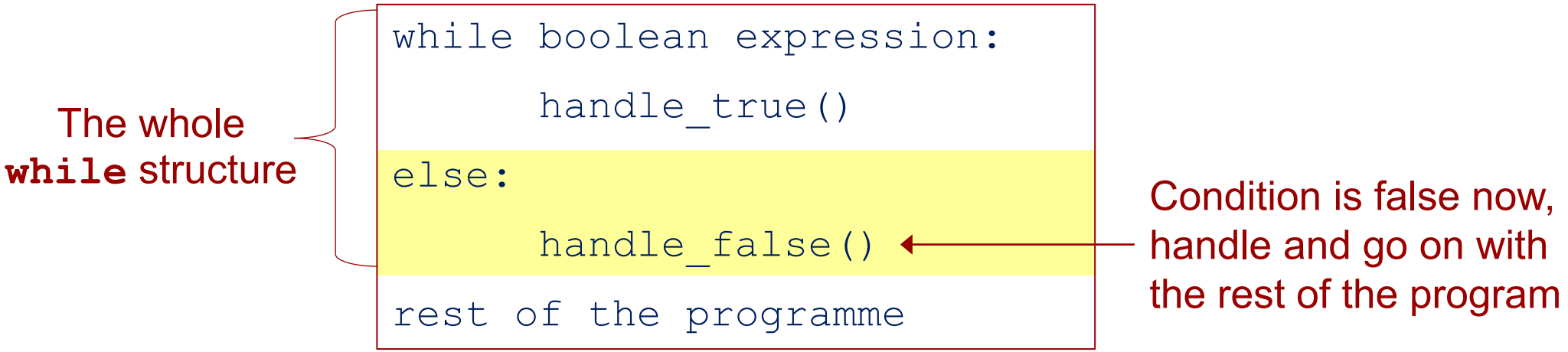
while structure

```
total = 0.0
item = float( input("Enter value: ") )
while item != -1:
    total += item
    item = float( input("Enter value: ") )
print("total=" , total )
```

Make sure **sentinel value** will not appear in normal inputs.

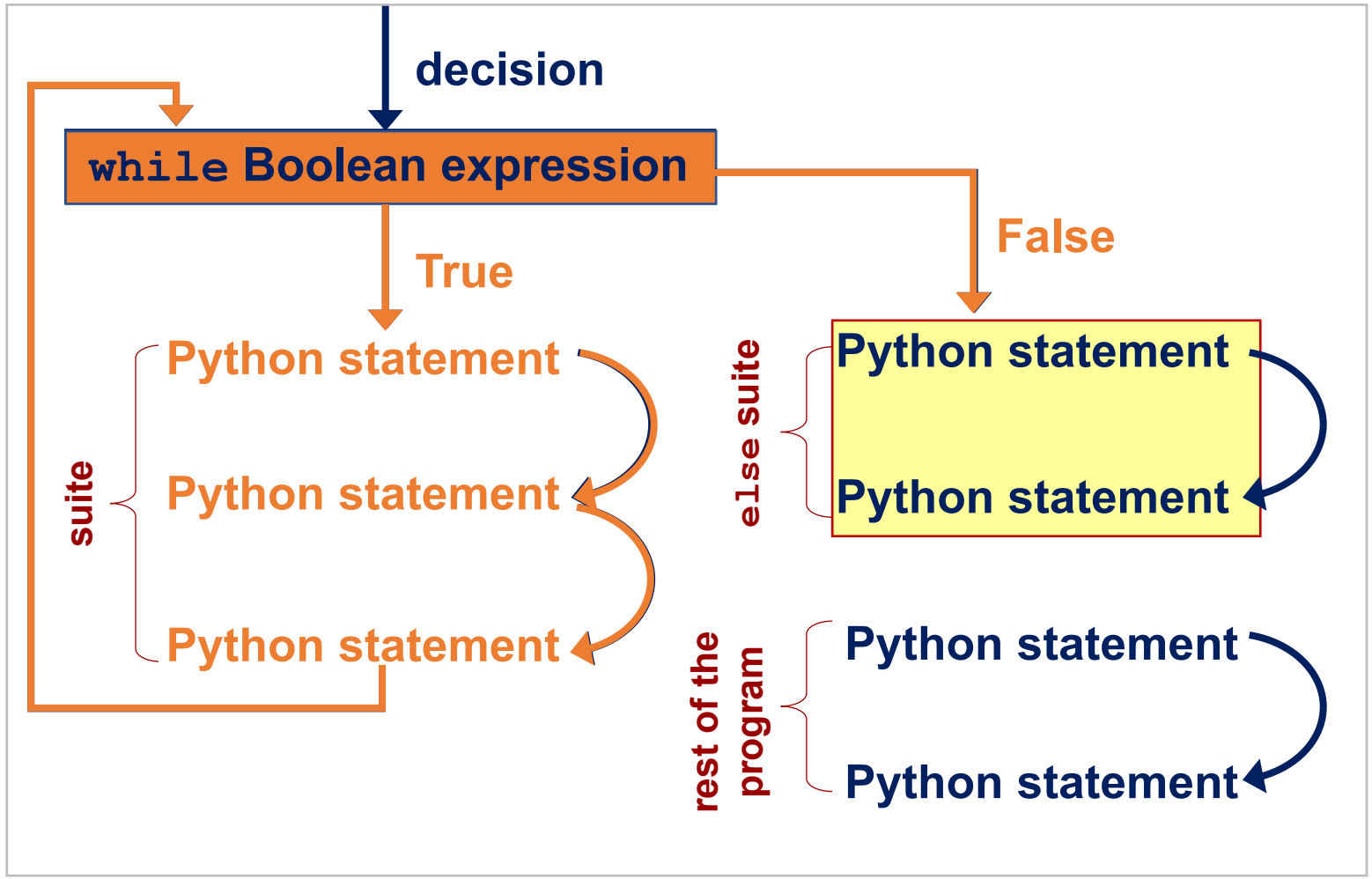
Do you foresee any issue to ensure for this design?

Loops in Python: `while-else` (Syntax)



- **`while`** loop, can have an associated **`else`** statement
- **`else`** statement is executed when the loop finishes under normal conditions
  - the last thing the loop does as it exits

Loops in Python: `while-else` (Syntax)



- It is entered after the `while` loop's Boolean expression becomes False.
- This entry occurs even when the expression is initially False and the `while` loop has never run.
- A handy way to perform some final tasks when the loop ends normally.

while-else: Example

```
total = 0.0
count = 0
item = float(input("Enter value:"))
while item != -1:
  total += item
  count += 1
  item = float(input("Enter value:"))
else:
  print (count, "numbers read.", "Total= ", total),
```

Enter value:-1
0 numbers read. Total= 0

Enter value:55
Enter value:21
Enter value:1
Enter value:-1
3 numbers read. Total= 77.0

Quick Check

What is the output of the following code?

```
value = 1
print ("before while", value)

while value <=3:
    value = value + 1
    print ("while", value)
else:
    print ("else", value)
```

Quick Check: Answer

What is the output of the following code?

```
value = 1
print ("before while", value)

while value <=3:
    value = value + 1
    print ("while", value)
else:
    print ("else", value)
```

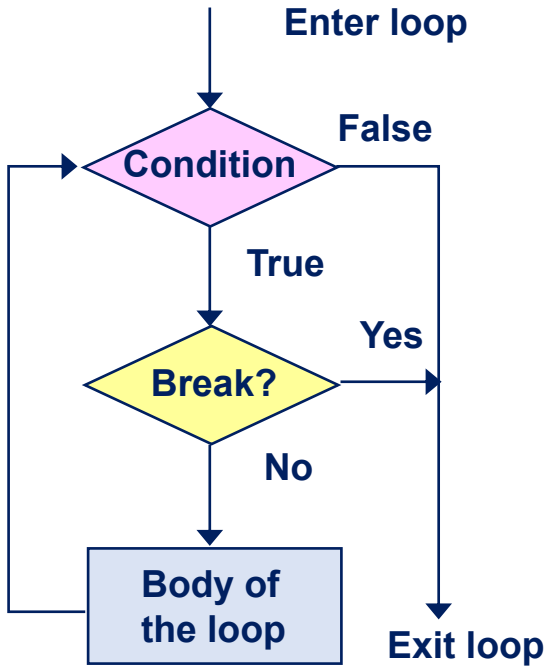
Answer

before while 1
while 2
while 3
while 4
else 4

`while-else`: Break Statement

- The **`break`** statement can be used to immediately exit the execution of the current loop and skip past all the remaining parts of the loop suite.
  - It is important to note that "skip past" means to skip the **`else`** suite (if it exists) as well.
- The **`break`** statement is useful for stopping computation when the "answer" has been found or when continuing the computation is otherwise useless.

Flowchart of a break



Working of break in a while loop

```
while test expression:
    body of while
    if condition
        break
    body of while

statements
```

Quick Try

What do you think is the output of the following code?

```
value = 1
print ("before while", value)

while value <=3:
    value = value + 1
    print ("while", value)
    if value == 2:
        break;
else:
    print ("else", value)

print ("after while", value)
```

Compared to quick check question: added **`if`** and **`break`**.

- Executing break exits the immediate loop that contains it.
- It goes after the whole enclosing loop.

Quick Try: Answer

What do you think is the output of the following code?

```
value = 1
print ("before while", value)

while value <=3:
    value = value + 1
    print ("while", value)
    if value == 2:
        break;
else:
    print ("else", value)

print ("after while", value)
```

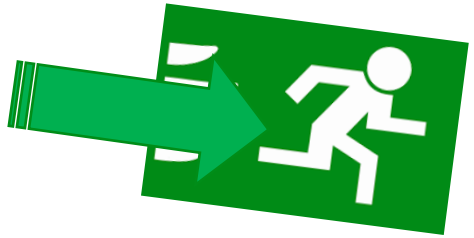
Answer

before while 1
while 2
after while 2

No more:
while 3
while 4
else 4

`while-else`: Break Statement (Cont'd)

Executing



Non-normal exit ⟺ Early exit

`while-else`: Break Statement – Example

"Hi-Low" Number Guessing Game

The program starts by generating a random number hidden from the user that is between 0 and 100. The user then attempts to guess the number, getting hints as to which direction (bigger or smaller, higher or lower) to go with the next guess.

The game can end in one of two ways:

- The correctly guessed the number.
- The user can quit playing by entering a number out of the range of 0 - 100.

`while-else`: Break Statement – Example (Cont'd)

"Hi-Low" Number Guessing Game

The program starts by generating a random number hidden from the user that is between 0 and 100. The user then attempts to guess the number, getting hints as to which direction (bigger or smaller, higher or lower) to go with the next guess.

The game can end in one of two ways:

- The user correctly guesses the number.
- The user can quit playing by entering a number out of the range of 0 - 100.

ALGORITHM

```
Choose a random number.
Prompt for a guess.
While the guess is in range:
    Check whether the guess is correct;
        If it is a win, print a win message and exit.
        Otherwise, provide a hint and prompt for a guess.
Else:
    User quits
```

while-else: Example 2 Python Code

```
Number = 67
print("Hi-Lo Number Guessing Game: between 0 and 100 inclusive.")
guess= (int)(input("Guess a number: "))
while 0 <= guess <= 100:
    if guess > Number:
        print("Guessed Too High.")
    elif guess < Number:
        print("Guessed Too Low.")
    else: # correct guess, exit with break
        print("You guessed it. The number was:",Number)
        break
    # keep going, get the next guess
    guess= (int)(input("Guess a number: "))
else:
    print("A pity. You quit the game early, the number was:",Number)
```

The else clause is often used in conjunction with the break statement.

while-else: Example 2 Python Code (Cont'd)

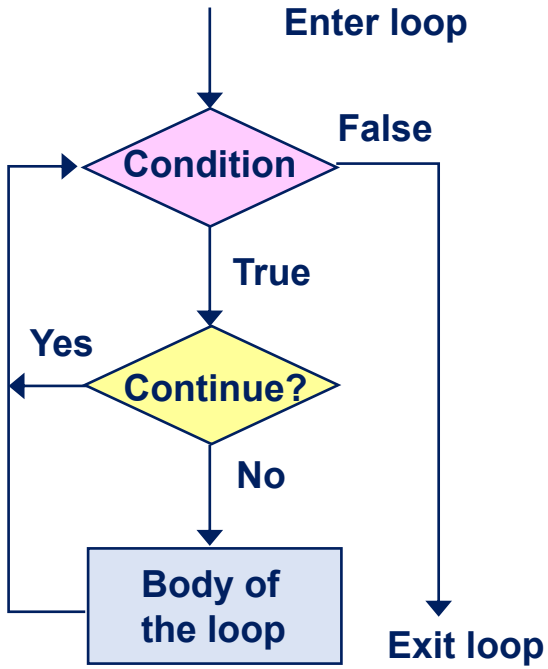
```
Number = 67
print("Hi-Lo Number Guessing Game: between 0 and 100 inclusive.")
guess= (int)(input("Guess a number: "))
while 0 <= guess <= 100:
    if guess > Number:
        print("Guessed Too High.")
    elif guess < Number:
        print("Guessed Too Low.")
    else: # correct guess, exit with break
        print("You guessed it. The number was:",Number)
        break
    # keep going, get the next guess
    guess= (int)(input("Guess a number: "))
else:
    print("A pity. You quit the game early, the number was:",Number)
```

Hi-Lo Number Guessing Game: between 0 and 100 inclusive.
Guess a number: 55
Guessed Too Low.
Guess a number: 88
Guessed Too High.
Guess a number: 234
A pity. You quit the game early, the number was: 67

`while-else`: Continue Statement

- Skip some portion of the **`while`** suite we are executing and have control flow back to the beginning of the **`while`** loop.
- Exit early from this iteration of the loop (not the loop itself), and keep executing the **`while`** loop.
- The **`continue`** statement continues with the next iteration of the loop.

Flowchart of a continue



Working of continue in a while loop

```
while test expression:
    body of while
    if condition
        continue
    body of while

statements
```

`while-else`: Continue Statement - Sample Problem

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Algorithm

Prompt the user for a number.

Convert the input string to an int.

If the input is even, add it to the running sum.

If the input is not even (odd), print an error message – don't add it to the sum, just continue on.

If the input is the special character ".", end and print the final sum.

`while-else`: Continue Statement – Solution to the Problem

```
# sum up a series of even numbers
# make sure only even numbers contribute to sum

print ("Allow the user to enter a series of even integers. Sum them.")
print ("Ignore non-even input. End input with a '.'")

# initialize the input number and the sum
number_str = input("Number: ")
the_sum = 0

# Stop if a period ( . ) is entered .
# remember , number_str is a string until we convert it
while number_str != "." :
    number = int(number_str)
    if number % 2 == 1: # number is not even ( it is odd)
        print ("Error, only even numbers please.")
        number_str = input("Number: ")
        continue # if the number is not even , ignore it
    the_sum += number
    number_str = input("Number: ")
print ("The sum is:",the_sum)
```

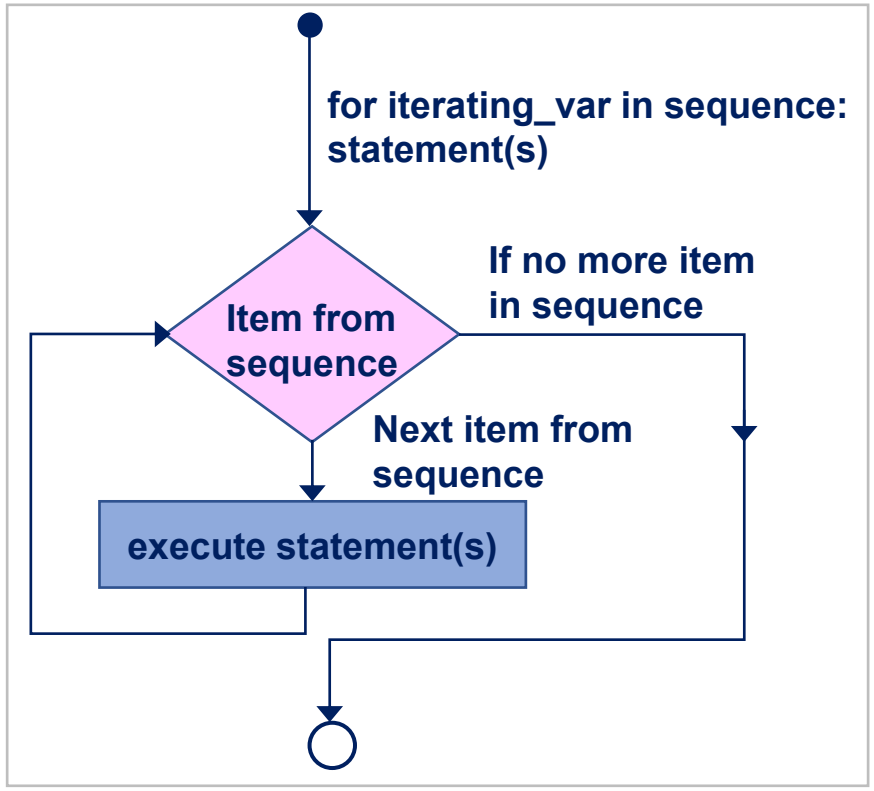
Control flow knowledge: Go immediately to test in the enclosing loop

Output:

```
Allow the user to enter a series of even integers. Sum them.
Ignore non-even input. End input with a '.'
Number: 7
Error, only even numbers please.
Number: 8
Number: 9
Error, only even numbers please.
Number: 4
Number: .
The sum is: 12
```

For `continue`, make sure loop control variable can be updated. Else, **infinite loop**.

Loops in Python: `for`



Syntax

```
for iterating_var in sequence:
   Suite (one or more indented statements)
```

- It has the ability to iterate over the items of any sequence, such as a list or a string.
- Each item in the sequence is assigned to the iterating variable iterating_var. Next, the statement(s) block is executed.
- The `for` loop completes when the last of the elements has been assigned to the iterating_var., i.e., the entire sequence is exhausted.

Loops in Python: `for` - Syntax

```
for iterating_var in <sequence>:
    Suite (one or more indented statements)
```

indentation

It must use a **colon** followed by proper **indentation**.

- Has a header and an associated suite.
- Keywords: **`for`** and **`in`**.
- The keyword **`in`** precedes the sequence.
- The variable iterating_var is a variable associated with the **`for`** loop that is assigned the value of an element in the sequence.
  - The variable iterating_var is assigned a different element during each pass of the **`for`** loop.
  - Eventually, iterating_var will be assigned to each element in the sequence.

Loops in Python: `for` - Example

Two `for` structures

It can also be a list

```
for the_char in 'thinking':
    print("current char:",the_char)

for the_drink in ["coffee", "tea", "milo"]:
    print("current drink:",the_drink)

print("enjoy")
```

Output

```
current char: t
current char: h
current char: i
current char: n
current char: k
current char: i
current char: n
current char: g
current drink: coffee
current drink: tea
current drink: milo
enjoy
```

Quick Check

Write a Python program to find the sum of the numbers from 1 to 10 using `for` loop.

Quick Check: Answer

Write a Python program to find the sum of the numbers from 1 to 10 using `for` loop.

Answer

```
sum = 0

for i in [1,2,3,4,5,6,7,8,9,10]:
  print("current i is :", i)
  sum += i

print ("the sum of the numbers from 1 to 10 is ", sum)
```

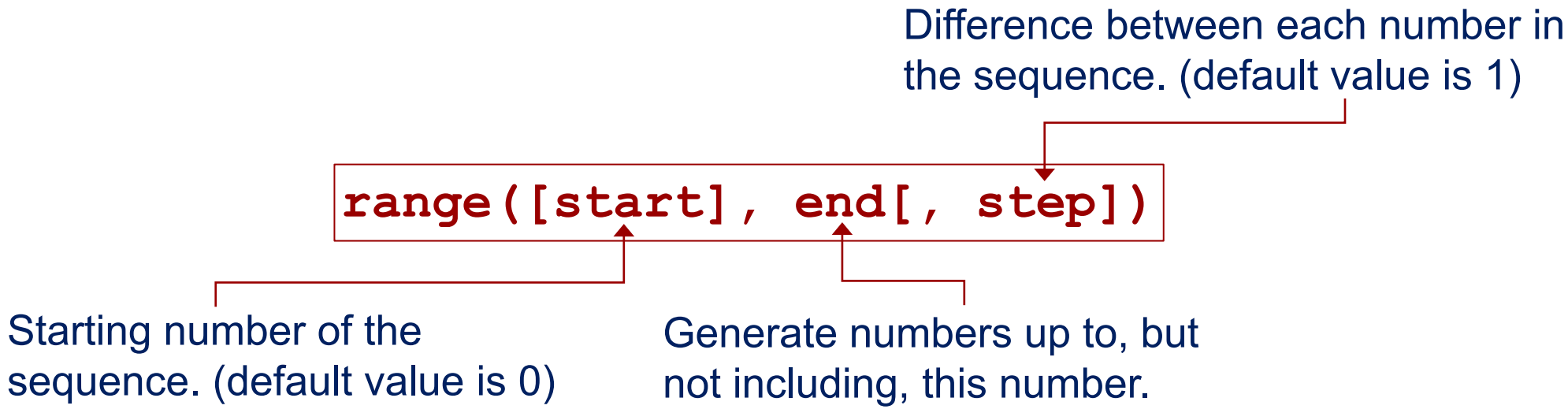
Output

```
current i is : 1
current i is : 2
current i is : 3
current i is : 4
current i is : 5
current i is : 6
current i is : 7
current i is : 8
current i is : 9
current i is : 10
the sum of the numbers from 1 to 10 is 55
```

Python: The Range Function

`range()`

- It is a useful built-in function in Python.
- It generates a list of integers from start up to end (but excluding end) with step-size step.



Note: All parameters must be integers, positive or negative.

Python: The Range Function - Variance

Syntax **Three different Forms:**

`range(end)`

- Python puts start to 0 and step to 1.
- **Example**: `range(11)` ➡ [0,1, 2, 3,…, 10]

`range(start, end)`

- Python puts step to 1 (default value).
- **Example**: `range(1, 11)` ➡ [1, 2, 3,…, 10]

`range(start, end, step)`

Examples:

`range(1, 11, 2)` ➡ [1, 3, 5, 7, 9]

`range(11, 2, -3)` ➡ [11, 8, 5]

Quick Check

What is the output of the following code?

```
sum = 0

for number in range(1,10):
    sum = sum + number

print (sum)
```

Quick Check: Answer

What is the output of the following code?

```
sum = 0

for number in range(1,10):
    sum = sum + number

print (sum)
```

Answer 45

Note: The range in Python excludes the ending element.

Quick Check

What is the output of the following code?

```
sum1 = sum2 = 0

for number in range(1,5,1):
    sum1 += number
for number in range(5,1,-1):
    sum2 += number

print ("sum1:", sum1, "sum2:", sum2)
```

Quick Check: Answer

What is the output of the following code?

```
sum1 = sum2 = 0

for number in range(1,5,1):        → [1, 2, 3, 4]
    sum1 += number
for number in range(5,1,-1):       → [5, 4, 3, 2]
    sum2 += number

print ("sum1:", sum1, "sum2:", sum2)
```

Answer **sum1: 10 sum2: 14**

Note:

- The sequence is not symmetric.

  range (1,5,1) != range (5,1,-1)

- Variable number in the example "**for**" loops will take different values in different loop iterations.

`range()`: Problem Example

Problem: Print a Multiplication Table of a Certain Number (Multiplier)

Example: 9 (multiplicands: from 1 to 10)

- First, ask the user for a number.
- Then loop from 1 to 10, compute the multiplication, and display the formulae.

```
==================
>>>
Enter a number between 1 to 9: 9
1 × 9 = 9
2 × 9 = 18
3 × 9 = 27
4 × 9 = 36
5 × 9 = 45
6 × 9 = 54
7 × 9 = 63
8 × 9 = 72
9 × 9 = 81
10 × 9 = 90
```

`range()`: Problem Example - Implementation in Python

In Python ⇒ just a few lines

```
num = int(input("Enter a number between 1 to 9: "))

for x in range (1,11):
    print (x , 'x' , num , '= ' , x*num)
```

Use comma to separate different elements for **print**.

End with 11 instead of 10 if we want the last value to be 10.

for-else-break-continue

```
for target in object:
    # statement suite1
    if boolean expression1:
        break  # Exit loop now; skip else
    if boolean expression2:
        continue  # Go to top of loop now
else:
    # statement suite2
```

Working of break in a for loop

```
for var in sequence:
    body of for
    if condition
        break
    body of for

statements
```

Working of continue in a while loop

```
while test expression:
    body of while
    if condition
        continue
    body of while

statements
```

Quick Check

What is the output of the following code?

```
for letter in "Python":
   if letter == 'h':
      break;
   print (letter, end = '')
```

Quick Check: Answer

What is the output of the following code?

```
for letter in "Python":
   if letter == 'h':
      break;
   print (letter, end = '')
```

Answer Pyt

Quick Check

What is the output of the following code?

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for letter in "Python":
   if letter == 'h':
      continue;
   print (letter, end = '')
```

Quick Check: Answer

What is the output of the following code?

```
for letter in "Python":
    if letter == 'h':
        continue;
    print (letter, end = '')
```

Answer Pyton

`for-else-break`: Computational Thinking Example

Prime or Non-Prime

Given a number k, how to determine if it is a prime?

- A prime number does not have other divisors except 1 and itself
- Find out whether a number is prime:
  1. Divide it by numbers smaller than it.
  2. If any of them have a zero remainder, then the number is not prime.

This is a job is for a `for` loop.

Logic

```
isprime = True
for n in range (1, k):
    if k%n == 0:
        isprime = False
```

The for loop ends at k/2.

Fact: It is not possible for any number larger than k/2 to divide evenly into k.

Reason

Is there a need to divide it by all the numbers smaller than it? → **No**

`for-else-break`: Computational Thinking Example

```
k = int(input("Please enter an integer: "))
# Divide k by all numbers 2<= n <= k/2
for n in range (2, int(k/2)+1):
    # If the remainder is 0 then n is a factor of k
    if k%n == 0:
        isprime = "no" # K is not a prime
        break #exit loop
else:
    isprime = "yes" # Loop not exited: it is prime
print(k, "is a prime? " , isprime)
```

Please enter an integer: 31
31 is a prime? yes

Please enter an integer: 32
32 is a prime? no

Nested Loops

Nested Loop a loop inside another loop

- Just as it is possible to have if statements nested within other if statements, a loop may appear inside another loop.
  - An outer loop may enclose an inner loop.

What can be nested?

- Nest as many levels of loops as the system allows.
- Nest different types of loops.

Nested Loops: Example 1

```
for y in range (1,4):#outer loop
  for x in range (1,6):#inner loop
    print('(', x, ',', y, ')', end = '')#inner loop body
    #end inner loop
  print()
  #end outer loop
```

This is the entire suite/ block inside the outer **for** loop.

Only one statement inside the inner **for** loop.

This additional argument is used in Python 3 to avoid the default ending \n.

```
( 1 , 1 ) ( 2 , 1 ) ( 3 , 1 ) ( 4 , 1 ) ( 5 , 1 )
( 1 , 2 ) ( 2 , 2 ) ( 3 , 2 ) ( 4 , 2 ) ( 5 , 2 )
( 1 , 3 ) ( 2 , 3 ) ( 3 , 3 ) ( 4 , 3 ) ( 5 , 3 )
```

- How many times each **print** is executed?
- What is the control flow?

Nested Loops: Example 2 - Printing Full Multiplication Table

```
m = int (input ("Enter a number between 1 to 9: ") )
n = int (input ("Enter another number between 1 to 9: "))
 for x in range (1,m+1):
   for y in range (1,n+1):
     print (x, 'x', y, '=', x*y, end ='')
   print()
```

Enter a number between 1 to 9: 3

Enter another number between 1 to 9: 4

1 x 1 = 1 1 x 2 = 2 1 x 3 = 3 1 x 4 = 4

2 x 1 = 2 2 x 2 = 4 2 x 3 = 6 2 x 4 = 8

3 x 1 = 3 3 x 2 = 6 3 x 3 = 9 3 x 4 = 12

In-Depth Nested Loops

- Loops can be nested to a greater depth if necessary, and **`while`** and **`for`** loops can be nested interchangeably.
- Is it ever useful to do this? ➡ Yes, very often.

Application **Test multiple numbers whether they are prime or not.**

- How many numbers to check? ➡ Unknown
- User enters '#' to end the checking.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Test Multiple Numbers - Prime or Not: Implementation

```
k_str = input("Please enter an integer: ")
while k_str != '#':
    k = int(k_str)
    # Divide k by all numbers 2<= n <= k/2
    for n in range (2, int(k/2)+1):
        # If the remainder is 0 then n is a factor of k
        if k%n == 0:
            isprime = "no" # k is not a prime
            break #exit for loop
    else:
        isprime = "yes" # loop not exited: it is prime
    print(k, "is a prime? " , isprime)
    k_str = input("Please enter another integer: ")
```

Output of a sample run

```
Please enter an integer: 31
31 is a prime? yes
Please enter another integer: 32
32 is a prime? no
Please enter another integer: 13
13 is a prime? yes
Please enter another integer: #
```

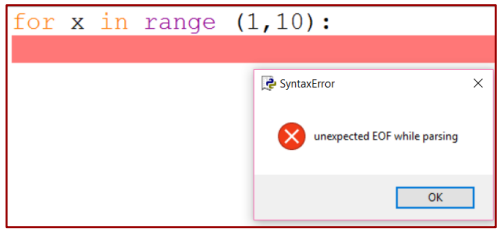
Note: **`break`** affects only that inner loop that contains it.

Interesting Pass Statement

- It has no effect (does nothing) but helps in **indicating** an empty statement/ suite/ block.
- Use when you have to put something in a statement (syntactically, you cannot leave it blank or Python will complain) but what you really want is nothing.

Python has the syntactical requirement that code blocks (after **`if`**, **`for`**, **`while`**, **`except`**, **`def`**, **`class`**, etc.) cannot be empty.

Example




```
for x in range (1,10):
    pass
```

Some uses of `pass`

- It can be used to test a statement (say, opening a file or iterating through a collection) just to see if it works.
- You can use **`pass`** as a place holder.

Quick Check

What is the output of the following code?

```
for letter in "Python":
   if letter == 'h':
      pass;
   print (letter, end = '')
```

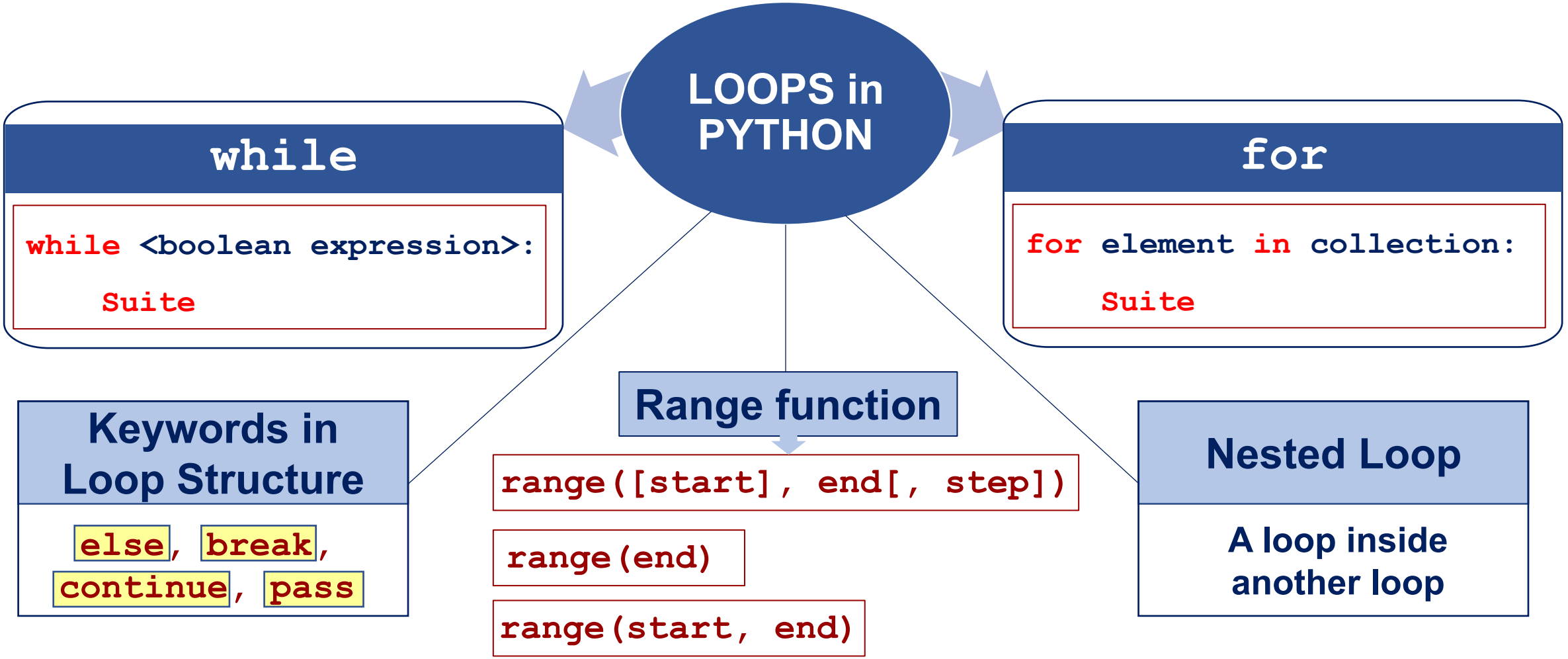
Quick Check: Answer

What is the output of the following code?

```
for letter in "Python":
   if letter == 'h':
      pass;
   print (letter, end = '')
```

Answer Python

Summary


LOOPS in PYTHON
while
while <boolean expression>:
Suite
for
for element in collection:
Suite
Keywords in Loop Structure
else, break, continue, pass
Range function
range([start], end[, step])
range(end)
range(start, end)
Nested Loop
A loop inside another loop