Common Loop Algorithms

Common Loop Algorithms

1. Sum and Average Value
2. Counting Matches
3. Prompting until a Match Is Found
4. Maximum and Minimum
5. Comparing Adjacent Values

Sum Example

- Sum of Values
  - Initialize total to 0
  - Use while loop with sentinel

```
total = 0.0
inputStr = input("Enter value: ")
while inputStr != "" :
    value = float(inputStr)
    total = total + value
    inputStr = input("Enter value: ")
```

Average Example

Average of Values

- First total the values
- Initialize count to 0
  - Increment per input
- Check for count 0
  - Before divide!

```
total = 0.0
count = 0
inputStr = input("Enter value: ")
while inputStr != "" :
   value = float(inputStr)
   total = total + value
   count = count + 1
   inputStr = input("Enter value: ")

if count > 0 :
   average = total / count
else :
   average = 0.0
```

Counting Matches (e.g., Negative Numbers)

- Counting Matches
  - Initialize negatives to 0
  - Use a while loop
  - Add to negatives per match

```
negatives = 0
inputStr = input("Enter value: ")
while inputStr != "“ :
    value = int(inputStr)
    if value < 0 :
        negatives = negatives + 1
    inputStr = input("Enter value: ")

print("There were", negatives,
"negative values.")
```

Prompt Until a Match is Found

- Initialize boolean flag to False
- Test sentinel in while loop
  - Get input, and compare to range
    - If input is in range, change flag to True
    - Loop will stop executing

```
valid = False
while not valid :
   value = int(input("Please enter a positive value < 100: "))
   if value > 0 and value < 100 :
      valid = True
   else :
      print("Invalid input.")
```

This is an excellent way to validate use provided inputs

Maximum

- Get first input value
  - By definition, this is the largest that you have seen so far
- Loop while you have a valid number (non-sentinel)
  - Get another input value
  - Compare new input to largest (or smallest)
  - Update largest if necessary

```
largest = int(input("Enter a value: "))
inputStr = input("Enter a value: ")
while inputStr != ””:
   value = int(inputStr)
   if value > largest :
      largest = value
   inputStr = input("Enter a value: ")
```

Minimum

- Get first input value
  - This is the smallest that you have seen so far!
- Loop while you have a valid number (non-sentinel)
  - Get another input value
  - Compare new input to largest (or smallest)
  - Update smallest if necessary

```
smallest = int(input("Enter a value: "))
inputStr = input("Enter a value: ")
while inputStr != "“ :
   value = int(inputStr)
   if value < smallest :
      smallest = value
   inputStr = input("Enter a value: ")
```

Comparing Adjacent Values

- Get first input value
- Use `while` to determine if there are more to check
  - Copy input to previous variable
  - Get next value into input variable
  - Compare input to previous, and output if same

```
value = int(input("Enter a value: "))
inputStr = input("Enter a value: ")
while inputStr != "“ :
   previous = value
   value = int(inputStr)
   if value == previous :
      print("Duplicate input")
   inputStr = input("Enter a value: ")
```

Grades Example

- Open the file:
  - Grades.py
- Look carefully at the source code.
- The maximum possible score is read as user input
  - There is a loop to validate the input
- The passing grade is computed as 60% of the available points

The **for** Loop

The `for` Loop

- Uses of a **`for`** loop:
  - The **`for`** loop can be used to iterate over the contents of any **container**.
  - A **container** is an object (Like a **string**) that contains or stores a collection of elements
  - A **string** is a container that stores the collection of characters in the string

while loop -> for loop

```
stateName = "Virginia"
i = 0
while i < len(stateName) :
    letter = stateName[i]
    print(letter)
    i = i + 1
```

while version

while loop -> for loop

```
stateName = "Virginia"
i = 0
while i < len(stateName) :
   letter = stateName[i]
   print(letter)
   i = i + 1
```

while version

```
stateName = "Virginia"
for letter in stateName :
   print(letter)
```

for version

while loop -> for loop

- Note an important difference between the while loop and the for loop.
- In the while loop, the *index variable* i is assigned 0, 1, and so on.
- In the for loop, the *element variable* is assigned stateName[0], stateName[1], and so on.

```
stateName = "Virginia"
i = 0
while i < len(stateName) :
   letter = stateName[i]
   print(letter)
   i = i + 1
```

while version

```
stateName = "Virginia"
for letter in stateName :
   print(letter)
```

for version

The for Loop (2)

- Uses of a for loop:
  - A for loop can also be used as a count-controlled loop that iterates over a range of integer values.

```
i = 1
while i < 10 :
   print(i)
   i = i + 1
```

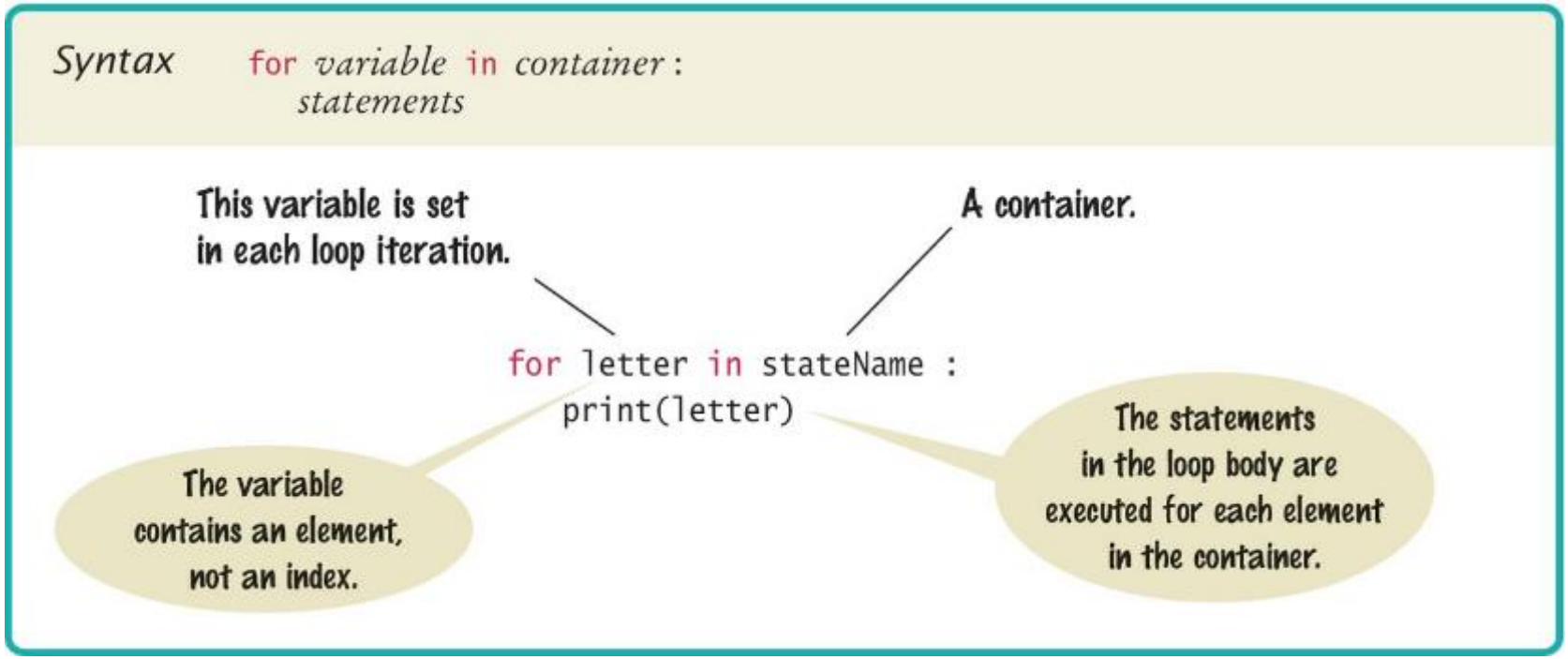
while version

```
for i in range(1, 10) :
   print(i)
```

for version

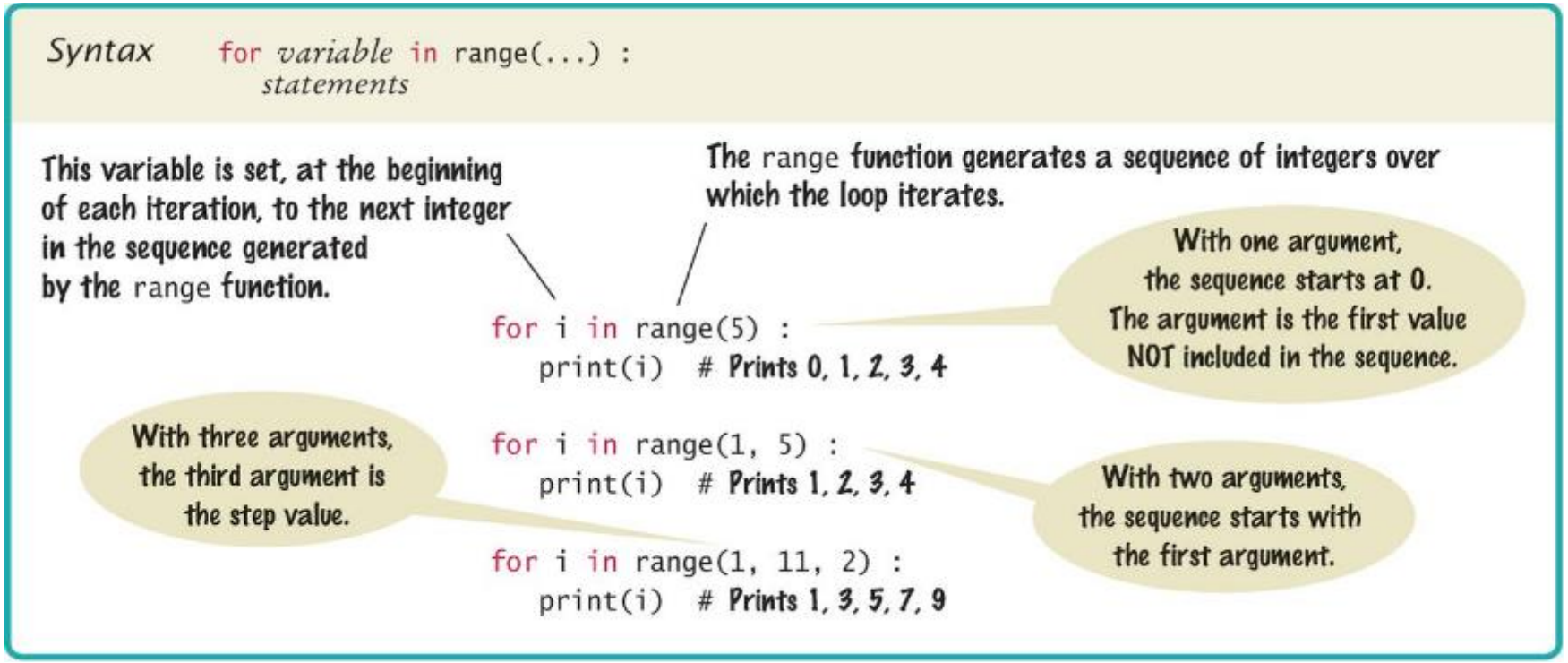
Syntax of a **for** Statement (Container)

- Using a for loop to iterate over the contents of a container, an element at a time.



Syntax of a **for** Statement (Range)

- You can use a for loop as a count-controlled loop to iterate over a range of integer values
- We use the range function for generating a sequence of integers that less than the argument that can be used with the for loop

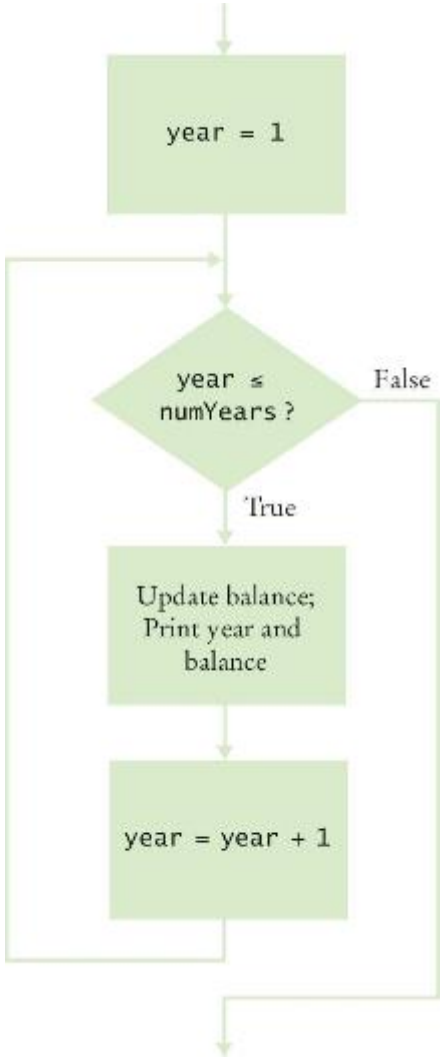


Planning a **for** Loop

- Print the balance at the end of each year for a number of years

Year	Balance
1	10500.00
2	11025.00
3	11576.25
4	12155.06
5	12762.82

```
for year in range(1, numYears + 1) :
    Update balance.
    Print year and balance.
```



Good Examples of **for** Loops

- Keep the loops simple!

Table 2 for Loop Examples

Loop	Values of i	Comment
`for i in range(6) :`	0, 1, 2, 3, 4, 5	Note that the loop executes 6 times.
`for i in range(10, 16) :`	10, 11, 12, 13, 14 15	The ending value is never included in the sequence.
`for i in range(0, 9, 2) :`	0, 2, 4, 6, 8	The third argument is the step value.
`for i in range(5, 0, -1) :`	5, 4, 3, 2, 1	Use a negative step value to count down.

Investment Example

```
1  ##
2  #  This program prints a table showing the growth of an investment.
3  #
4
5  # Define constant variables.
6  RATE = 5.0
7  INITIAL_BALANCE = 10000.0
8
9  # Obtain the number of years for the computation.
10 numYears = int(input("Enter number of years: "))
11
12 # Print the table of balances for each year.
13 balance = INITIAL_BALANCE
14 for year in range(1, numYears + 1) :
15    interest = balance * RATE / 100
16    balance = balance + interest
17    print("%4d %10.2f" % (year, balance))
```

Programming Tip

- Finding the correct lower and upper bounds for a loop can be confusing.
  - Should you start at 0 or at 1?
  - Should you use <= b or < b as a termination condition?
- Counting is easier for loops with asymmetric bounds.
  - The following loops are executed b - a times.

```
int i = a
while i < b :
   . . .
   i = i + 1
```

```
for i in range(a, b) :
   . . .
```

Programming Tip

- The loop with symmetric bounds ("<=", is executed b - a + 1 times.
  - That "+1" is the source of many programming errors.

```
i = a
while i <= b :
   . . .
   i = i + 1
```

```
# For  this version of the loop the
'+1' is very noticeable!
for year in range(1, numYears + 1) :
```

Summary of the **for** Loop

- **for** loops are very powerful
- The **for** loop can be used to iterate over the contents of any container, which is an object that contains or stores a collection of elements
  - a string is a container that stores the collection of characters in the string.
- A **for** loop can also be used as a count-controlled loop that iterates over a range of integer values.

Steps to Writing a Loop

- Planning:
  - Decide what work to do inside the loop
  - Specify the loop condition
  - Determine loop type
  - Setup variables before the first loop
  - Process results when the loop is finished
  - Trace the loop with typical examples
- Coding:
  - Implement the loop in Python

A Special Form of the `print` Function

- Python provides a special form of the print function that does not start a new line after the arguments are displayed
- This is used when we want to print items on the same line using multiple print statements
- For example the two statements:

```
print(“00”, end=””)
print(3 + 4)
```

- Produce the output:

```
007
```

- Including **end=“”** as the last argument to the print function prints an empty string after the arguments, instead on a new line
- The output of the next **print** function starts on the same line

Nested Loops

Loops Inside of Loops

- In Chapter Three we learned how to nest **if** statements to allow us to make complex decisions
  - Remember that to nest the **if** statements we need to indent the code block
- Complex problems sometimes require a nested loop, one loop nested inside another loop
  - The nested loop will be indented inside the code block of the first loop
- A good example of using nested loops is when you are processing cells in a table
  - The outer loop iterates over all of the rows in the table
  - The inner loop processes the columns in the current row

Our Example Problem Statement

- Print a Table Header that contains x^1, x^2, x^3, and x^4
- Print a Table with four columns and ten rows that contain the powers of x^1, x^2, x^3, and x^4 for x = 1 to 10

x^1	x^2	x^3	x^4
1	1	1	1
2	4	8	16
3	9	27	81
…	…	…	…
10	100	1000	10000

Applying Nested Loops

- How would you print a table with rows and columns?
  - Print top line (header)
    - Use a for loop
  - Print table body…
    - How many rows are in the table?
    - How many columns in the table?
  - Loop per row
    - Loop per column
- In our example there are:
  - Four columns in the table
  - Ten rows in the table

x^1	x^2	x^3	x^4
1	1	1	1
2	4	8	16
3	9	27	81
…	…	…	…
10	100	1000	10000

Pseudocode to Print the Table

Print the table header

```
for x from 1 to 10
  print a new table row
  print a new line
```

- How do we print a table row?

```
For n from 1 to 4
  print x^n
```

- We have to place this loop inside the preceding loop
  - The inner loop is *"nested"* inside the outer loop

Pseudocode to Print the Table

Print the table header:

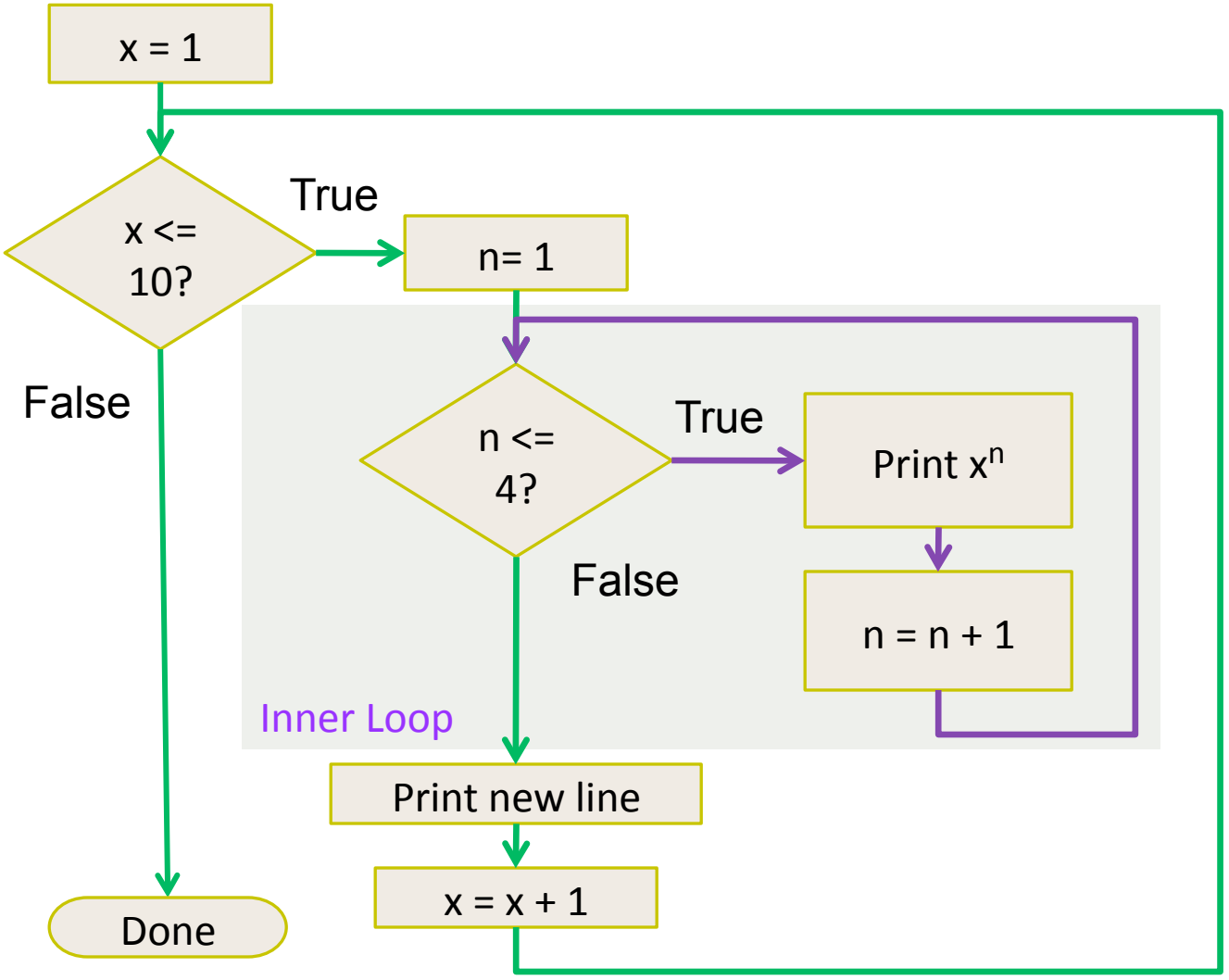
```
for x from 1 to 10
  for n from 1 to 4
    print Xⁿ
  print a new line
```

x ↓

n →

x^1	x^2	x^3	x^4
1	1	1	1
2	4	8	16
3	9	27	81
…	…	…	…
10	100	1000	10000

Flowchart of a Nested Loop



Powertable.py

```
1   #
2   #  This program prints a table of powers of x.
3   #
4
5   # Initialize constant variables for the max ranges.
6   NMAX = 4
7   XMAX = 10
8
9   # Print table header.
10  #
11
12  for n in range(1, NMAX + 1) :
13     print("%10d" % n, end="")
14
15  print()
16  for n in range(1, NMAX + 1) :
17     print("%10s" % "x ", end="")
18
19  print("\n", "    ", "-" * 35)
20
21  # Print table body.
22  #
23
24  for x in range(1, XMAX + 1) :
25     # Print the x row in the table.
26     for n in range(1, NMAX + 1) :
27        print("%10.0f" % x ** n, end="")
28
29     print()
30
```

The **end=“”** suppresses the new line, so the numbers are all printed on the same line

Body of outer loop, x = 1 ➔ 10

Body of inner loop, n = 1 ➔ 4

The Results

```
[evaluate Powertable header.py]
          1           2           3           4
          x           x           x           x
  ------------------------------------------------
          1           1           1           1
          2           4           8          16
          3           9          27          81
          4          16          64         256
          5          25         125         625
          6          36         216        1296
          7          49         343        2401
          8          64         512        4096
          9          81         729        6561
         10         100        1000       10000
```

First Exercise

- Open the program:
  - powertable.py
- Run the program and review the results
- Make the following changes:
  - Change the value of NMAX to 6 and run the program
  - What changes in the table?
  - Change the value of NMAX back to 4
  - Change the value of XMAX to 4
  - What changes in the table?

Nested Loop Examples

Table 3 Nested Loop Examples

Nested Loops	Output	Explanation

`for i in range(3) :`
`  for j in range(4) :`
`  print("*", end="")`
`  print()`
	****
	****
	****
		Prints 3 rows of 4 asterisks each.

`for i in range(4) :`
`  for j in range(3) :`
`  print("*", end="")`
`  print()`
	***
	***
	***
	***
		Prints 4 rows of 3 asterisks each.

`for i in range(4) :`
`  for j in range(i + 1) :`
`  print("*", end="")`
`  print()`
	*
	**
	***
	****
		Prints 4 rows of lengths 1, 2, 3, and 4.

Hand Tracing the Loop

```
1  for i in range(4) :
2      for j in range(i + 1) :
3          print("*", end="")
4      print()
```

- i will have the values:
  - 0, 1, 2, 3 – So we will have four lines of stars
- j will have the values
  - 0 - So we will have one star
  - 0, 1 - So we will have two stars
  - 0, 1, 2 - So we will have three stars
  - 0, 1, 2, 3 - So we will have four stars

```
[evaluate nested loop example three.py]
*
**
***
****
```

Nested Loop Examples (2)

Table 3 Nested Loop Examples

`for i in range(3) :`
`  for j in range(5) :`
`  if j % 2 == 1 :`
`  print("*", end="")`
`  else :`
`  print("-", end="")`
`  print()`
	-*-*-
	-*-*-
	-*-*-
		Prints alternating dashes and asterisks.

`for i in range(3) :`
`  for j in range(5) :`
`  if i % 2 == j % 2 :`
`  print("*", end="")`
`  else :`
`  print(" ", end="")`
`  print()`
	* * *
	 * *
	* * *
		Prints a checkerboard pattern.

Second Problem Statement

- Print the following pattern of brackets:
  []][]][]
  []][]][]
  []][]][]
- The pattern consists of:
  - Three rows
  - Each row has four pairs of brackets
- What do we know?
  - We need two nested loops
    - The first loop (the outer loop) will print each of the three rows
    - The second loop (the inner loop) will print the four pairs of brackets

Pseudocode Code, Results

```
For i = 1 to 3
  For j = 1 to 4
    Print “[]”
  Print a new line
```

```
1  for i in range(3) :
2      for j in range(4) :
3          print("[]", end="")
4      print()
```

```
[evaluate nested loop example three.py]
[][][][]
[][][][]
[][][][]
```

Exam Averages Problem Statement

- It is common to repeatedly read and process multiple groups of values:
  - Write a program that can compute the average exam grade for multiple students.
  - Each student has the same number of exam grades
  - Prompt the user for the number of exams
  - When you finish a student prompt the user to see if there are more students to process
- What do we know?
- What do we need to compute?
- What is our algorithm / approach?

Step One: Understand the Problem

- To compute the average grade for a student, we must read and tally all of the grades for that student
  - We can use a loop to do this. ***(we have working code to do this portion)***
- We need to compute grades for multiple students
  - That implies a set of nested Loops
    - The outer loop processes each student
    - The inner loop process the student's grades

Step Two

- Compute the grade for one student
- Set up the variables and loop
- We know how many grades to process, so we can use a count-controlled loop

```
total score = 0
For i in range (1, number of exams + 1) :
  Read the next exam score
  Add the exam score to the total score
Compute the exam average
Print the exam average
```

Step Three

- Repeat the process for each student
- Since we don't know how many students there are, we will use a while loop with a sentinel value
  - For simplicity we will use "Y" as the sentinel value

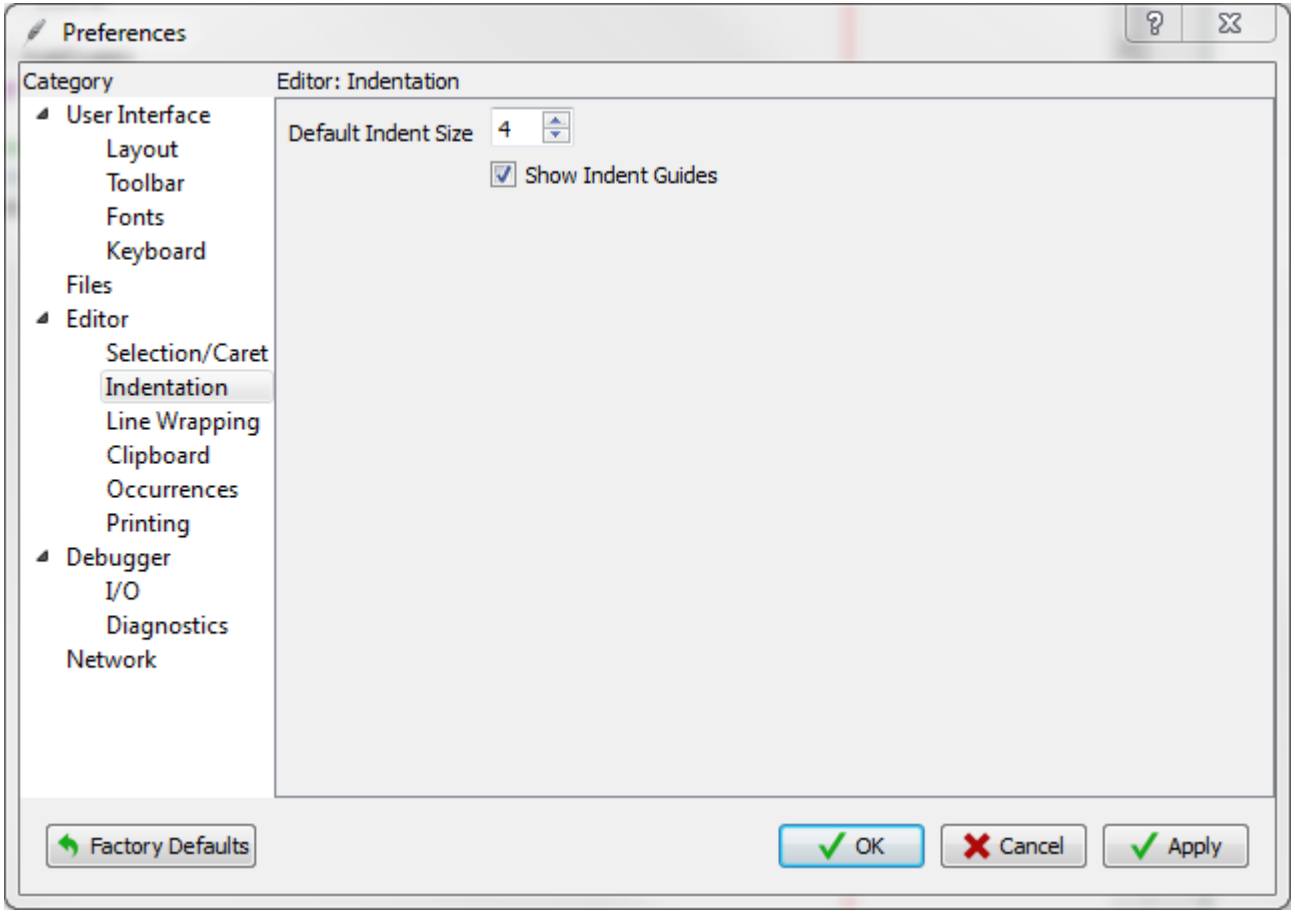
Step Four: Translate to Python

```
1   ##
2   #  This program computes the average exam grade for multiple students.
3   #
4
5   # Obtain the number of exam grades per student.
6   numExams = int(input("How many exam grades does each student have? "))
7
8   # Initialize moreGrades to a non-sentinel value.
9   moreGrades = "Y"
10
11  # Compute average exam grades until the user wants to stop.
12  while moreGrades == "Y" :
13
14      # Compute the average grade for one student.
15      print("Enter the exam grades.")
16      total = 0
17      for i in range(1, numExams + 1) :
18          score = int(input("Exam %d: " % i))   # Prompt for each exam grade.
19          total = total + score
20
21      average = total / numExams
22      print("The average is %.2f" % average)
23
24      # Prompt as to whether the user wants to enter grades for another student.
25      moreGrades = input("Enter exam grades for another student (Y/N)? ")
26      moreGrades = moreGrades.upper()
```

Exam Averages Example

- Open the file:
  - examaverages.py
- Notice that the second loop (the **for** loop) is nested inside the **while** loop
- In Wing you should see a line (the indent guide) connecting the **for** loop on line 17 down to the statement on line 21
  - The line is showing you the statements that are included in the **for** loop
- If you don't see the indent guide:
  - Click on the edit tab
  - Select "Preferences…"
  - Under Editor, select Indention
  - Click the "Show Indent Guides" box
  - Click the Apply button
  - Click the Okay Button

Turning the Indent Guides On



Application: Random Numbers and Simulations

Random Numbers/Simulations

- Games often use random numbers to make things interesting
  - Rolling Dice
  - Spinning a wheel
  - Pick a card
- A simulation usually involves looping through a sequence of events
  - Days
  - Events

Generating Random Numbers

- The Python library has a *random number generator* that produces numbers that appear to be random
  - The numbers are not completely random. The numbers are drawn from a sequence of numbers that does not repeat for a long time
  - random() returns a number that is >= 0 and < 1

Simulating Die Tosses

- Goal:
  - To generate a random integer in a given range we use the randint() function
  - Randint has two parameters, the range (inclusive) of numbers generated

ch04/dice.py

```
1  ##
2  #  This program simulates tosses of a pair of dice.
3  #
4
5  from random import randint
6
7  for i in range(10) :
8     # Generate two random numbers between 1 and 6, inclusive.
9     d1 = randint(1, 6)
10    d2 = randint(1, 6)
11
12    # Print the two values.
13    print(d1, d2)
```

Program Run

```
1 5
6 4
1 1
4 5
6 4
3 2
4 2
3 5
5 2
4 5
```