COMPSCI 101

Principles of Programming

Lecture 12 – Loops, while loops

Learning outcomes

At the end of this lecture, students should:

- understand the concept of a loop for defining repeated tasks
- understand the structure of a while loop, i.e.,
    - the loop initialisation
    - the body of the loop
    - the loop condition
    - the loop increment
- be able to design and write Python while loops

Recap

From lecture 11

- the `if` block of an `if…else` statement is executed only if the boolean expression evaluates to `True`, otherwise the `else` block is executed.
- `if…elif` statements are useful if there is a situation where at most one option is to be selected from many options. The `if…elif` statement has an optional final `else` part.

```
def get_random_horoscope():
    message = "Lucky lucky you"
    number = random.randrange(10)
    if number < 4:
        message = "Amazing day ahead"
    elif number < 7:
        message = "Romance is very likely"
    elif number < 8:
        message = "Proceed with caution"
    return message

def main():
    print("Today's message:", get_random_horoscope())
    print("Today's message:", get_random_horoscope())

main()
```

```
Today's message: Romance is very likely
Today's message: Amazing day ahead
```

Control structures

It is important to understand how the computer works its way through the program statements, i.e., the order in which instructions are executed.

Control structures allow us to change the flow of statement execution in our programs. So far we have looked at selection statements (`if` statements). Selection or if statements are also called branch statements, as, when the program arrives at an if statement, control will "branch" off into one of two or more "directions".

Now we will look at another control structure, **iteration**. Iteration means that the same code is executed repeatedly.

Some examples where iteration is required are:

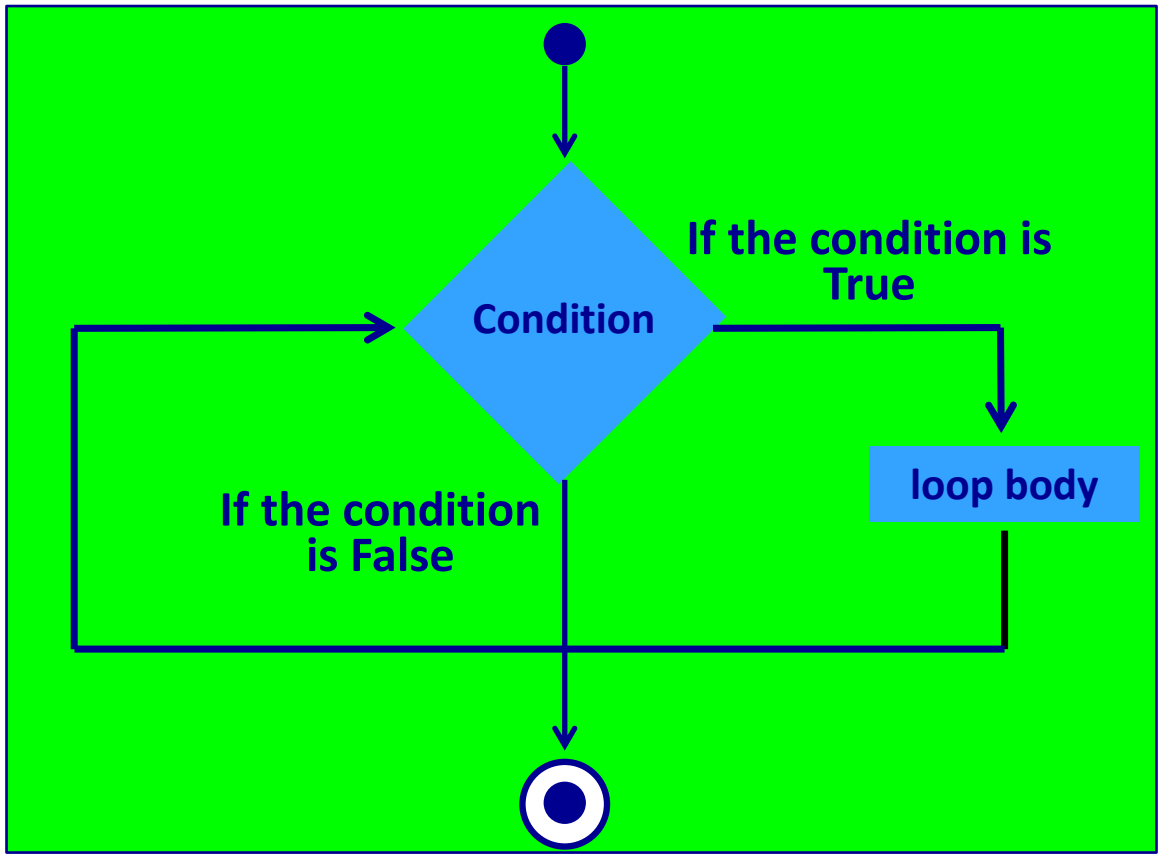
- User login – asking for the password until the correct one is given
- Menu option control – menu options are repeatedly displayed and processed until the ‘exit’ option is selected

Iteration – while loops

We use loops to implement iteration.

How does the while loop execute?

```
while boolean_expression:
    statement1
    statement2
    statement3
    …
```



First, the condition is tested.

If the condition evaluates to True, the loop statements (the loop body) are executed.

After the loop statements have been executed, control returns to top of the loop, and the condition is tested again.

As long as the condition evaluates to True, the loop statements are executed.

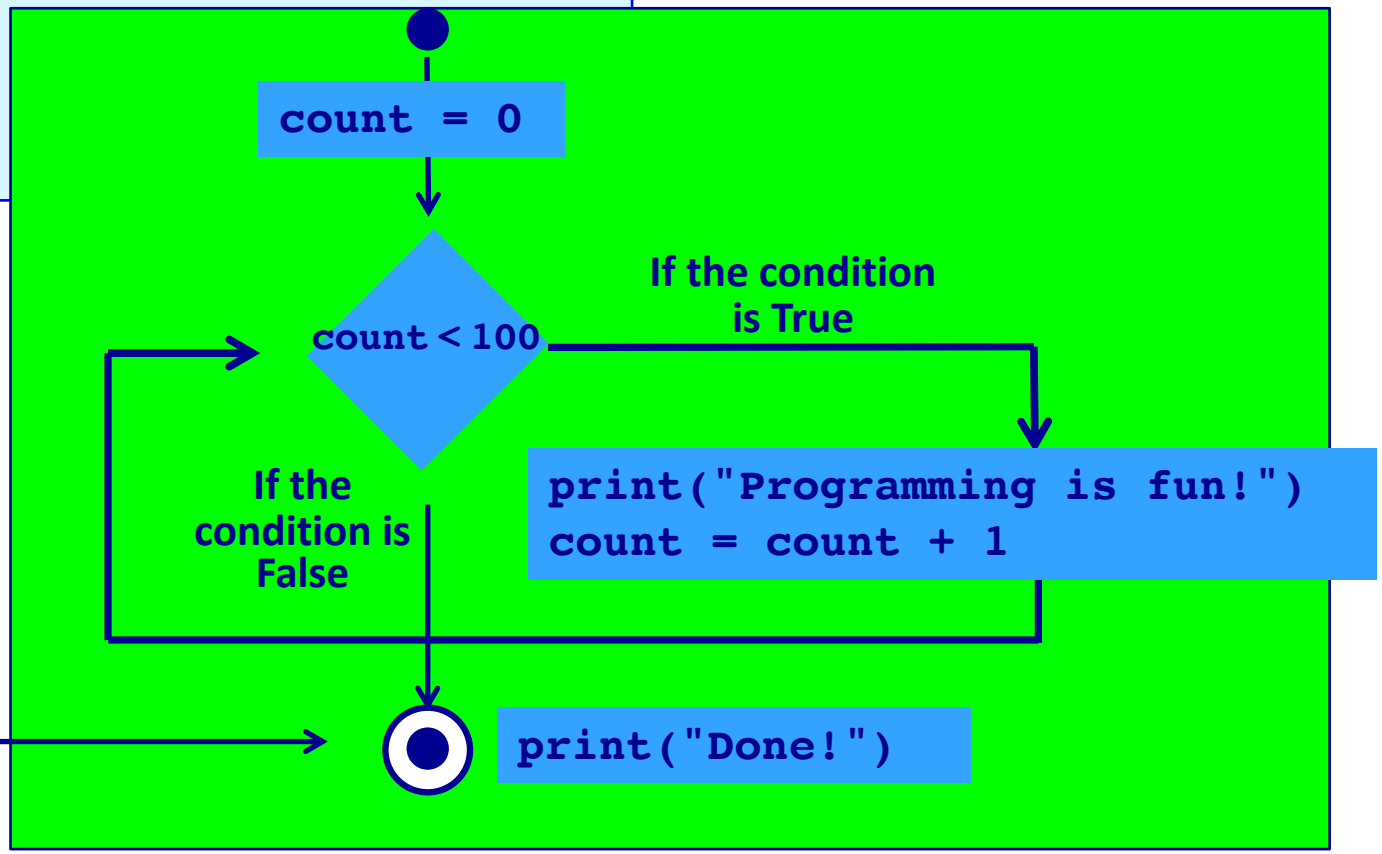
while loop - example

```
1  def print_lines():
2      count = 0
3      while count < 100:
4          print("Programming is fun!")
5          count = count + 1
6      print("Done!")

7  def main():
8      print_lines()

9  main()
```

```
Programming is fun!
Programming is fun!
Programming is fun!
…
Programming is fun!
Done!
```



When the condition becomes False the control moves on to the code after the loop (line 6 in the code above).

while loop - terminology

```
1  def print_lines():
2      count = 0
3      while count < 100:
4          print("Programming is fun!")
5          count = count + 1
6      print("Done!")
7  def main():
8      print_lines()
9  main()
```

initialisation

condition

body

increment

```
Programming is fun!
Programming is fun!
...
Done!
```

Initialisation: anything which needs to be done before the loop starts.
condition: a boolean expression which is tested repeatedly to determine whether the body of the loop should be executed or not.

body: the statements which are to be executed over and over (or not at all).

increment: this changes the loop variable so that eventually the condition becomes false. Remember that a loop will only stop when the condition is false.

while loop – no overt increment

Sometimes we don't need an overt increment statement, e.g.,

```
1  def total_user_numbers():
2     total = 0
3     number = int(input("Enter a number (0 to end): "))
4     while number != 0:
5         total = total + number
6         number = int(input("Enter a number (0 to end): "))
7     print("Total: ", total)
8  def main():
9     total_user_numbers()
10 main()
```

```
Enter a number (0 to end): 5
Enter a number (0 to end): 6
Enter a number (0 to end): 2
Enter a number (0 to end): 4
Enter a number (0 to end): 0
Total:  17
```

Give the output

```
def display_output():
   number = 1
   count = 10
   value = 4

   while count > 4:
       count = count - 2
       print(str(number) + ":", count, value)
       value = value + count
       number = number + 1

   print()
   print(str(number) + ":", count, value)

def main():
   display_output()

main()
```

Suppressing the new line after printing

The `print()` function has an optional argument, **`sep = "…"`** which can be used to set the separator between the arguments of the `print()` statement (the default is a blank space).

```
print(1, "Meravigioso", "Fabulous", sep = "*")
print('The final results are:', 56, "and", 44, sep = "")
```

1*Meravigioso*Fabulous
The final results are:56and44

The `print()` function has an optional argument, **`end = "…"`** which can be used to set the character/s which is/are to be inserted after the arguments have been printed (the default is a new line character).

```
print("The", end = " ")
print("cat", end = "*")
print("said", end = "")
print("nothing", end = "!")
print()
print("Enough said!")
```

The cat*saidnothing!
Enough said!

Complete the function

The `get_dice_throws_result()` function throws a number of dice (given by `num_throws`) and counts how often the dice value, (given by `dice_to_check`) occurs. Complete the function.

```
import random
def get_dice_throws_result(num_throws, dice_to_check):









def main():
   print("30000 throws,", get_dice_throws_result(30000, 6),
                                                  "sixes")
   print("6 throws,", get_dice_throws_result(6, 6), "sixes")
   print("600000 throws,", get_dice_throws_result(600000, 5),
                                                  "fives")

main()
```

```
30000 throws, 4913 sixes
6 throws, 0 sixes
600000 throws, 99929 fives
```

Complete the function

For an integer, a divisor is a number which divides exactly into the integer (a factor of the integer), e.g., the divisors of 6 are 1, 2, 3, 6. Note that 1 and the number itself are divisors (they divide into the number exactly). For this function we only want the sum of all the divisors less than the number itself. Complete the function.

```
def get_sum_of_divisors(number):
```

```
get_sum_of_divisors(6) 6
get_sum_of_divisors(24) 36
get_sum_of_divisors(25) 6
get_sum_of_divisors(5628) 9604
```

```
def main():
    print("get_sum_of_divisors(6)", get_sum_of_divisors(6))
    print("get_sum_of_divisors(24)", get_sum_of_divisors(24))
    print("get_sum_of_divisors(25)", get_sum_of_divisors(25))
    print("get_sum_of_divisors(5628)", get_sum_of_divisors(5628))

main()
```

Complete the function

A perfect number is an integer that is equal to the sum of its divisors (including 1, excluding the number itself), e.g., the sum of the divisors of 28 is 28 (1 + 2 + 4 + 7 + 14). Complete the **`check_perfection()`** function which checks for perfection and prints either `'#is a perfect number'` or `'#is NOT a perfect number'`.

```
def get_sum_of_divisors(number):
   #See code from the previous Slide

def check_perfection(number):
   message_is = "is a perfect number"
   message_is_not = "is NOT a perfect number"



def main():
   check_perfection(28)
   check_perfection(54)
   check_perfection(496)

main()
```

```
28 is a perfect number
54 is NOT a perfect number
496 is a perfect number
```

Complete the function

Complete the `user_number_guess()` function which keeps prompting the user to guess a hidden number until the user correctly guesses the number. At each guess the function lets the user know if the guess is too high or too low. At the end, the function also prints the number of guesses taken.

```
def user_number_guess(computer_num):
    prompt = "Enter your guess (1 - 99): "
    num_guesses = 0









    print("Correct! Number of guesses:", num_guesses)
def main():
    user_number_guess(random.randrange(1, 100))

main()
```

```
Enter your guess (1 - 99): 50
Too high
Enter your guess (1 - 99): 25
Too high
Enter your guess (1 - 99): 13
Too low
Enter your guess (1 - 99): 20
Too low
Enter your guess (1 - 99): 23
Correct! Number of guesses: 5
```

Summary

- In a Python program:
  - a loop is used to implement repetition
  - a loop has four parts
    - the loop initialisation
    - the body of the loop
    - the loop condition
    - the loop increment

  - a while loop has the following syntax:

```
while boolean_expression:
    statement1
    statement2
    …
```

Examples of Python features used in this lecture

```
def get_sum_of_divisors(number):
    divisor = 1
    div_sum = 0

    while divisor <= number // 2:
        if number % divisor == 0:
            div_sum = div_sum + divisor
        divisor = divisor + 1

    return div_sum

def fun_stuff():
    count = 0
    while count < 4:
        print("Programming is fun!")
        count = count + 1
```