MODULE 2

CONDITIONAL EXECUTION, ITERATION & STRINGS

2.1 CONDITIONAL EXECUTION

In general, the statements in a program will be executed sequentially. But sometimes we need a set of statements to be executed based on some conditions. Such situations are discussed in this section.

2.1.1 Floor division and modulus

The floor division operator, //, divides two numbers and rounds down to an integer. For example, suppose the run time of a movie is 105 minutes. You might want to know how long that is in hours. Conventional division returns a floating-point number:

```
>>> minutes = 105
>>> minutes / 60
1.75
```

But we don't normally write hours with decimal points. Floor division returns the integer number of hours, rounding down:

```
>>> minutes = 105
>>> hours = minutes // 60
>>> hours
1
```

To get the remainder, you could subtract off one hour in minutes:

```
>>> remainder = minutes - hours * 60
>>> remainder
45
```

An alternative is to use the modulus operator, %, which divides two numbers and returns the remainder.

```
>>> remainder = minutes % 60
>>> remainder
45
```

The modulus operator is more useful than it seems. For example, you can check whether one number is divisible by another—if x % y is zero, then x is divisible by y. Also, you can extract the right-most digit or digits from a number. For example, x % 10 yields the right-most digit of x (in base 10). Similarly, x % 100 yields the last two digits. If you are using Python 2, division works differently. The division operator, /, performs floor division if both operands are integers, and floating-point division if either operand is a float.

2.1.2 Boolean Expressions

A *Boolean Expression* is an expression which results in *True* or *False*. The *True* and *False* are special values that belong to class ***bool.*** Check the following –

```
>>> type(True)
<class 'bool'>
>>> type(False)
<class 'bool'>
```

Boolean expression may be as below –

```
>>> 10==12
False
>>> x=10
>>> y=10
>>> x==y
True
```

Various comparison operations are shown in Table 2.1.

Table 2.1 Relational (Comparison) Operators

Operator	Meaning	Example
>	Greater than	a>b
<	Less than	a<b
>=	Greater than or equal to	a>=b
<=	Less than or equal to	a<=b
==	Comparison	a==b
!=	Not equal to	a !=b
is	Is same as	a is b
is not	Is not same as	a is not b

Few Examples:

```
>>> a=10
>>> b=20
>>> x= a>b
>>> print(x)
False
```

```
>>> print(a==b)
False
>>> print("a<b is ", a<b)
a<b is True
>>> print("a!=b is", a!=b)
a!=b is True
>>> 10 is 20
False
>>> 10 is 10
True
```

NOTE: For a first look, the operators = = and *is* look same. Similarly, the operators *!*= and *is not* look the same. But, the operators == and *!*=does the ***equality test.*** That is, they will compare the values stored in the variables. Whereas, the operators *is* and *is not* does the ***identity test***. That is, they will compare whether two objects are same. Usually, two objects are same when their memory locations are same. This concept will be more clear when we take up classes and objects in Python.

2.1.3 Logical Operators

There are 3 logical operators in Python as shown in Table 2.2. (NOTE that symbols like &&, || are not used in Python for representing logical operators)

Table 2.2 Logical Operators

Operator	Meaning	Example
`and`	Returns true, if both operands are true	`a and b`
`or`	Returns true, if any one of two operands is true	`a or b`
`not`	Return true, if the operand is false (it is a unary operator)	`not a`

NOTE:

1. Logical operators treat the operands as Boolean (True or False).
2. Python treats any non-zero number as True and zero as False.
3. While using *and* operator, if the first operand is False, then the second operand is not evaluated by Python. Because *False and'*ed with anything is False.
4. In case of *or* operator, if the first operand is True, the second operand is not evaluated. Because *True or'*ed with anything is True.

Example 1 (with Boolean Operands)**:**

```
>>> x= True
>>> y= False
>>> print('x and y is', x and y)
x and y is False
>>> print('x or y is', x or y)
x or y is True
>>> print('Complement of x is ', not x)
Complement of x is False
```

Example 2 (With numeric Operands)**:**

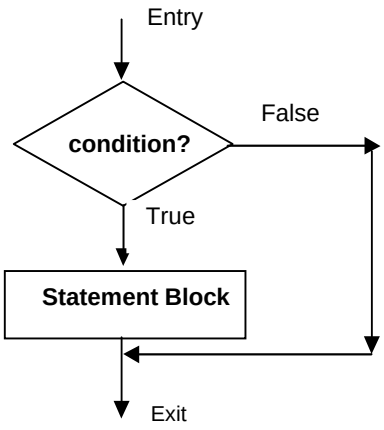
```
>>> a=-3
>>> b=10
>>> print(a and b)        #and operation
10          #a is true, hence b is evaluated and printed

>>> print(a or b)         #or operation
-3                  #a is true, hence b is not evaluated
>>> print(0 and 5)        #0 is false, so printed
0
```

2.1.4 Conditional Execution

The basic level of conditional execution can be achieved in Python by using *if* statement. The syntax and flowcharts are as below –

```
if condition:
      Statement block
```



Observe the colon symbol after *condition*. When the *condition* is true, the *Statement block* will beexecuted. Otherwise, it is skipped. A set (block) of statements to be executed under *if* is decided by the indentation (tab space) given.

Consider an example –

```
>>> x=10
>>> if x<35:
       print("Fail")   #observe indentation after if

Fail                   #output
```

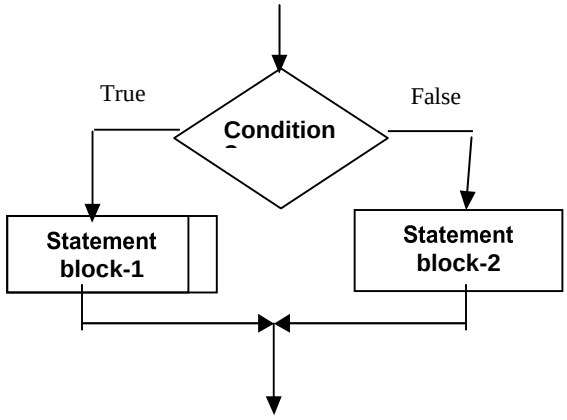
Usually, the *if* conditions have a statement block. In any case, the programmer feels to do nothing when the condition is true, the statement block can be skipped by just typing ***pass*** statement as shown below –

```
>>> if x<0:
          pass              #do nothing when x is negative
```

2.1.5 Alternative Execution

A second form of *if* statement is *alternative execution*. Here, when the condition is true, one set of statements will be executed and when the condition is false, another set of statements will be executed. The syntax and flowchart are as given below –

```
if condition:
   Statement block-1
else:
   Statement block-2
```



As the *condition* will be either true or false, only one among *Statement block-1* and *Statement block-2* will be get executed. Thesetwo alternatives are known as ***branches.***

Example:

```
x=int(input("Enter x:"))
if x%2==0:
     print("is even number")
else:
     print("is odd number")
```

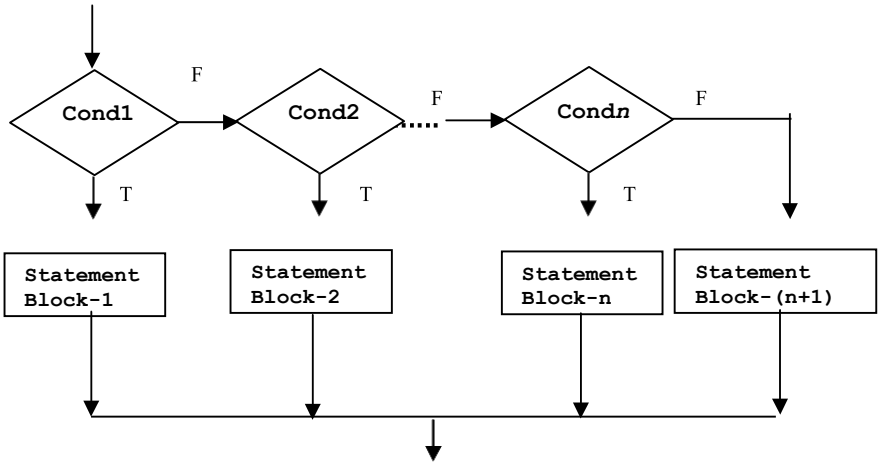
Sample output:

Enter x: 13 is odd number

2.1.6 Chained Conditionals

Some of the programs require more than one possibility to be checked for executing a set of statements. That means, we may have more than one branch. This is solved with the help of *chained conditionals*. The syntax and flowchart is given below –

```
if condition1:
      Statement Block-1
elif condition2:
      Statement Block-2
      |
      |
      |
      |
elif condition_n:
      Statement Block-n
else:
      Statement Block-(n+1)
```



The conditions are checked one by one sequentially. If any condition is satisfied, the respective statement block will be executed and further conditions are not checked. Note that, the last *else* block is not necessary always.

Example:

```
marks=float(input("Enter marks:"))
if marks >= 80:
    print("First Class with Distinction")
elif marks >= 60 and marks < 80:
    print("First Class")
elif marks >= 50 and marks < 60:
    print("Second Class")
elif marks >= 35 and marks < 50:
    print("Third Class")
else:
     print("Fail")
```

Sample Output:

```
Enter marks: 78
First Class
```

2.1.7 Nested Conditionals

The conditional statements can be nested. That is, one set of conditional statements can be nested inside the other. It can be done in multiple ways depending on programmer's requirements. Examples are given below –

Ex1.
```
marks=float(input("Enter marks:"))
if marks>=60:
    if marks<70:
        print("First Class")
    else:
        print("Distinction")
```

Sample Output:
Enter marks:68 First Class

Here, the outer condition marks>=60 is checked first. If it is true, then there are two branches for the inner conditional. If the outer condition is false, the above code does nothing.

Ex2.
```
gender=input("Enter gender:")
age=int(input("Enter age:"))

if gender == "M" :if age >= 21:
        print("Boy, Eligible for Marriage")
else:
        print("Boy, Not Eligible for Marriage")
elif gender == "F":
    if age >= 18:
        print("Girl, Eligible for Marriage")
else:
        print("Girl, Not Eligible for Marriage")
```

Sample Output:
Enter gender: F
Enter age: 17
Girl, Not Eligible for Marriage

NOTE: Nested conditionals make the code difficult to read, even though there are proper indentations. Hence, it is advised to use logical operators like *and* to simplify the nested conditionals. For example, the outer and inner conditions in **Ex1** above can be joined as -

```
if marks>=60 and marks<70:#do something
```

2.1.8 Catching Exceptions using try and except

As discussed in Section 1.1.11, there is a chance of runtime error while doing some program. One of the possible reasons is wrong input. For example, consider the following code segment –

```
a=int(input("Enter a:"))
b=int(input("Enter b:"))
c=a/b
print(c)
```

When you run the above code, one of the possible situations would be –

```
Enter a:12Enter b:0
Traceback (most recent call last):
  File "C:\Users\Manojkumar\Python\Python39\p1.py",
line 154,in <module>
    c=a/b
ZeroDivisionError: division by zero
```

For the end-user, such type of system-generated error messages is difficult to handle. So the code which is prone to runtime error must be executed conditionally within *try* block. The ***try*** block contains the statements involving suspicious code and the ***except*** block contains the possible remedy (or instructions to user informing what went wrong and what could be the way to get out of it). If something goes wrong with the statements inside ***try*** block, the ***except*** block will be executed. Otherwise, the except-block will be skipped. Consider the example –

```
a=int(input("Enter a:"))
b=int(input("Enter b:"))
try:
    c=a/b print(c)
except:
    print("Division by zero is not possible")
```

Output:

```
Enter a:12Enter b:0
Division by zero is not possible
```

Handling an exception using *try* is called as ***catching*** an exception. In general, catching an exception gives the programmer to fix the probable problem, or to try again or at least to end the program gracefully.

2.1.9 Recursion

It is legal for one function to call another; it is also legal for a function to call itself. It may not be obvious why that is a good thing, but it turns out to be one of the most magical things a program can do. For example, look at the following function:

```
def countdown(n):
   if n <= 0:
      print('Blastoff!')
   else:
      print(n)
countdown(n-1)
```

If n is 0 or negative, it outputs the word, "Blastoff!" Otherwise, it outputs n and then calls a function named countdown—itself—passing n-1 as an argument.

What happens if we call this function like this?

```
>>> countdown(3)
```

- The execution of countdown begins with n=3, and since n is greater than 0, it outputs the value 3, and then calls itself...
- The execution of countdown begins with n=2, and since n is greater than 0, it outputs the value 2, and then calls itself...
- The execution of countdown begins with n=1, and since n is greater than 0, it outputs the value 1, and then calls itself...
- The execution of countdown begins with n=0, and since n is not greater than 0, it outputs the word, "Blastoff!" and then returns.

The countdown that got n=1 returns.
The countdown that got n=2 returns.
The countdown that got n=3 returns.
And then you're back in __main__. So, the total output looks like this:

```
3
2
1
```
Blastoff!

A function that calls itself is **recursive**; the process of executing it is called **recursion**.

As another example, we can write a function that prints a string n times.

```
def print_n(s, n):
    if n <= 0:
       return
    print(s)
print_n(s, n-1)
```

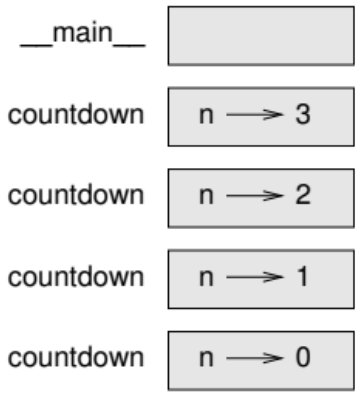


Figure 2.1: Stack Diagram of Recursion

If n <= 0 the **return statement** exits the function. The flow of execution immediately returns to the caller, and the remaining lines of the function don't run.

The rest of the function is similar to countdown: it displays s and then calls itself to displays *n* - 1 additional times. So the number of lines of output is 1 + (n - 1), which adds upto n.

For simple examples like this, it is probably easier to use a for loop. But we will see examples later that are hard to write with a for loop and easy to write with recursion, so it is good to start early.

2.2 ITERATION

Iteration is a processing repeating some task. In a real-time programming, we require a set of statements to be repeated certain number of times and/or till a condition is met. Every programming language provides certain constructs to achieve the repetition of tasks. In this section, we will discuss various such looping structures.

2.2.2 The *while* Statement

The *while* loop has the syntax as below –

```
while condition:
      statement_1
      statement_2
      …….
      statement_n

statements_after_while
```

Here, ***while*** is a keyword. The condition is evaluated first. Till its value remains true, the statement_1 to statement_n will be executed. When the condition becomes false, the loop is terminated and statements after the loop will be executed. Consider an example –

```
n=1
while n<=5:
    print(n)    #observe indentation
    n=n+1

print("over")
```

The output of above code segment would be –

```
1
2
3
4
5
over
```

In the above example, a variable n is initialized to 1. Then the condition n<=5 is being checked. As the condition is true, the block of code containing print statement (print(n))and

increment statement (n=n+1)are executed. After these two lines, condition is checkedagain. The procedure continues till condition becomes false, that is when n becomes 6. Now, the while-loop is terminated and next statement after the loop will be executed. Thus, in this example, the loop is ***iterated*** for 5 times.

Note that, a variable n is initialized before starting the loop and it is incremented inside the loop. Such a variable that changes its value for every iteration and controls the total execution of the loop is called as ***iteration variable*** or ***counter variable***. If the count variable is not updated properly within the loop, then the loop may not terminate and keeps executing infinitely.

2.2.3 Infinite Loops, *break* and *continue*

A loop may execute infinite number of times when the condition is never going to become false. For example,

```
n=1
while True:
     print(n) n=n+1
```

Here, the condition specified for the loop is the constant True, which will never get terminated. Sometimes, the condition is given such a way that it will never become false and hence by restricting the program control to go out of the loop. This situation may happen either due to wrong condition or due to not updating the counter variable.

In some situations, we deliberately want to come out of the loop even before the normal termination of the loop. For this purpose, ***break*** statement is used. The following example depicts the usage of *break***.** Here, the values are taken from keyboard until a negative number is entered. Once the input is found to be negative, the loop terminates.

```
while True:
    x=int(input("Enter a number:"))
    if x>= 0:
        print("You have entered ",x)
    else:
        print("You have entered a negative number!!")
        break       #terminates the loop
```

Sample output:

```
Enter a number:23
You have entered 23
Enter a number:12
You have entered 12
Enter a number:45
You have entered 45
Enter a number:0
You have entered 0
Enter a number:-2
You have entered a negative number!!
```

In the above example, we have used the constant True as condition for while-loop, which will never become false. So, there was a possibility of infinite loop. This has been avoided by using *break* statement with a condition. The condition is kept inside the loop such a way that, if the user input is a negative number, the loop terminates. This indicates that, theloop may terminate with just one iteration (if user gives negative number for the very first time) or it may take thousands of iteration (if user keeps on giving only positive numbers as input). Hence, the number of iterations here is unpredictable. But, we are making sure thatit will not be an infinite-loop, instead, the user has control on the loop.

Sometimes, programmer would like to move to next iteration by skipping few statements in the loop, based on some condition. For this purpose ***continue*** statement is used. For example, we would like to find the sum of 5 even numbers taken as input from the keyboard. The logic is –

- Read a number from the keyboard
- If that number is odd, without doing anything else, just move to next iteration forreading another number
- If the number is even, add it to *sum* and increment the accumulator variable.
- When accumulator crosses 5, stop the programThe program for the above task can

be written as –

```
sum=0, count=0
while True:
    x=int(input("Enter a number:"))
    if x%2 !=0:
        continue
    else:
       sum+=x
```

```
            count+=1

            if count==5:
              break

    print("Sum= ", sum)
```

Sample Output:

```
Enter a number:13
Enter a number:12
Enter a number:4
Enter a number:5
Enter a number:-3
Enter a number:8
Enter a number:7
Enter a number:16
Enter a number:6
Sum=  46
```

2.2.4 Definite Loops using *for*

The *while* loop iterates till the condition is met and hence, the number of iterations are usually unknown prior to the loop. Hence, it is sometimes called as *indefinite loop*. Whenwe know total number of times the set of statements to be executed,

```
for var in list/sequence:
      statement_1
      statement_2
      ……..
      statement_n

statements_after_for
```

for loop will be used. This is called as a *definite loop***.** The for-loop iterates over a set of numbers, a set of words, lines in a file etc. The syntax of for-loop would be –

Here,	*for* and *in*	are keywords
	list/sequence	is a set of elements on which the loop is iterated. That is, the loop will be executed till there is an element in list/sequence
	statements	constitutes body of the loop

Ex: In the below given example, a ***list*** names containing three strings has been created. Then the counter variable x in the *for*-loop iterates over this *list*. The variable x takes the elements in namesone by one and the body of the loop is executed.

```
names=["Rama", "Shyama", "Bhama"]
for x in names:
    print(x)
```

The output would be –

```
Rama Shyama Bhama
```

NOTE: In Python, list is an important data type. It can take a sequence of elements of different types. It can take values as a comma separated sequence enclosed within square brackets. Elements in the list can be extracted using index (just similar to extracting array elements in C/C++ language). Various operations like indexing, slicing, merging, addition and deletion of elements etc. can be applied on lists. The details discussion on Lists will be done in Module 3.

The *for* loop can be used to print (or extract) all the characters in a string as shown below –

```
for i in "Hello":
    print(i, end='\t')
```

Output:

```
H    e    l    l    o
```

When we have a fixed set of numbers to iterate in a *for* loop, we can use a function ***range()***. The function *range()* takes the following format –

```
range(start, end, steps)
```

The start and end indicates starting and ending values in the sequence, where end is excluded in the sequence (That is, sequence is up to end-1). The default value of startis 0. The argument steps indicates the increment/decrement in the values of sequence with the default value as 1. Hence, the argument steps is optional. Let us consider few examples on usage of *range()* function.

Ex1. Printing the values from 0 to 4 –

```
for i in range(5):
    print(i, end= '\t')
```

Output:

```
0    1    2    3    4
```

Here, 0 is the default starting value. The statement `range(5)` is same as `range(0,5)` and `range(0,5,1)`.

Ex2. Printing the values from 5 to 1 –

```
for i in range(5,0,-1):
    print(i, end= '\t')
```

Output: `5 4 3 2 1`

The function `range(5,0,-1)` indicates that the sequence of values are 5 to 0(excluded) in steps of -1 (downwards).

Ex3. Printing only even numbers less than 10 –

```
for i in range(0,10,2):
    print(i, end= '\t')
```

Output:

```
0    2    4    6    8
```

2.2.5 Loop Patterns

The *while*-loop and *for*-loop are usually used to go through a list of items or the contents of a file and to check maximum or minimum data value. These loops are generally constructed by the following procedure –

- Initializing one or more variables before the loop starts
- Performing some computation on each item in the loop body, possibly changing the variables in the body of the loop
- Looking at the resulting variables when the loop completes

The construction of these loop patterns are demonstrated in the following examples.

Counting and Summing Loops: One can use the *for* loop for counting number of items in the list as shown –

```
count = 0
for i in [4, -2, 41, 34, 25]:
    count = count + 1
print("Count:", count)
```

Here, the variable count is initialized before the loop. Though the counter variable iis not being used inside the body of the loop, it controls the number of iterations. The variable count is incremented in every iteration, and at the end of the loop the total number of elements in the list is stored in it.

One more loop similar to the above is finding the sum of elements in the list –

```
total = 0
for x in [4, -2, 41, 34, 25]:
    total = total + x
print("Total:", total)
```

Here, the variable `total` is called as ***accumulator*** because in every iteration, it accumulates the sum of elements. In each iteration, this variable contains *running total of values so far*.

NOTE: In practice, both of the counting and summing loops are not necessary, because there are built-in functions `len()` and `sum()` for the same tasks respectively.

Maximum and Minimum Loops: To find maximum element in the list, the following code can be used –

```
big = None
print('Before Loop:', big)
for x in [12, 0, 21,-3]:
    if big is None or x > big :
        big = x
    print('Iteration Variable:', x, 'Big:', big)

print('Biggest:', big)
```

Output:

```
Before Loop: None
Iteration Variable: 12   Big: 12
Iteration Variable: 0    Big: 12
Iteration Variable: 21   Big: 21
Iteration Variable: -3   Big: 21
Biggest: 21
```

Here, we initialize the variable big to None. It is a special constant indicating empty. Hence, we cannot use relational operator == while comparing it with big. Instead, the ***is*** operator must be used. In every iteration, the counter variable x is compared with previous value of big. If x > big, then x is assigned to big.

Similarly, one can have a loop for finding smallest of elements in the list as given below –

```
small = None
print('Before Loop:', small)
```

```
for x in [12, 0, 21,-3]:
    if small is None or x < small :
       small = x
    print('Iteration Variable:', x, 'Small:', small)

print('Smallest:', small)
```

Output:

```
Before Loop: None
Iteration Variable: 12 Small: 12
Iteration Variable: 0 Small: 0
Iteration Variable: 21 Small: 0
Iteration Variable: -3 Small: -3
Smallest: -3
```

NOTE: In Python, there are built-in functions `max()` and `min()` to compute maximum and minimum values among. Hence, the above two loops need not be written by the programmer explicitly. The inbuilt function `min()` has the following code in Python –

```
def min(values):
     smallest = None
     for value in values:
          if smallest is None or value < smallest:
               smallest = value
     return smallest
```

2.3 STRINGS

A string is a sequence of characters, enclosed either within a pair of single quotes or double quotes. Each character of a string corresponds to an index number, starting with zero as shown below –

S= "Hello World"

character	H	e	l	l	o		w	o	r	l	d
index	0	1	2	3	4	5	6	7	8	9	10

The characters of a string can be accessed using index enclosed within square brackets. For example,

```
>>> word1="Hello"
>>> word2='hi'
>>> x=word1[1]      #2nd character of word1 is extracted
>>> print(x)
    e
>>> y=word2[0]      #1st character of word1 is extracted
```

```
>>> print(y)
     h
```

Python supports negative indexing of string starting from the end of the string as shown below –

S= "Hello World"

character	H	e	l	l	o		w	o	r	l	D
Negative index	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1

The characters can be extracted using negative index also. For example,

```
>>> var="Hello"
>>> print(var[-1])
o
>>> print(var[-4])
e
```

Whenever the string is too big to remember last positive index, one can use negative index to extract characters at the end of string.

2.3.2 Getting Length of a String using *len()*

The ***len()*** function can be used to get length of a string.

```
>>> var="Hello"
>>> ln=len(var)
>>> print(ln)
     5
```

The index for string varies from 0 to length-1. Trying to use the index value beyond this range generates error.

```
>>> var="Hello"
>>> ln=len(var)
>>> ch=var[ln]
IndexError: string index out of range
```

2.3.3 Traversal through String with a Loop

Extracting every character of a string one at a time and then performing some action on that character is known as *traversal.* A string can be traversed either using *while* loop or using *for* loop in different ways. Few of such methods is shown here –

- **Using *for* loop:**

```
st="Hello"
for i in st:
     print(i, end='\t')
```

Output:

```
H    e    l    l    o
```

In the above example, the *for* loop is iterated from first to last character of the string `st`. That is, in every iteration, the counter variable `i` takes the values as H, e, l, l and o. The loop terminates when no character is left in `st`.

- **Using *while* loop:**

```
st="Hello"
i=0
while i<len(st):
     print(st[i], end='\t')
     i+=1
```

Output:

```
H    e    l    l    o
```

In this example, the variable i is initialized to 0 and it is iterated till the length of the string. In every iteration, the value of i is incremented by 1 and the character in a string is extracted using ias index.

2.3.4 String Slices

A segment or a portion of a string is called as *slice*. Only a required number of characters can be extracted from a string using colon (:) symbol. The basic syntax for slicing a string would be –

```
st[i:j:k]
```

This will extract character from i^{th} character of `st` till $(j-1)^{th}$ character in steps of k. If first index iis not present, it means that slice should start from the beginning of the string. If the second index `j` is not mentioned, it indicates the slice should be till the end of the string. The third parameter `k`, also known as ***stride***, is used to indicate number of steps to be incremented after extracting first character. The default value of stride is 1.

Consider following examples along with their outputs to understand string slicing.

```
st="Hello World"        #refer this string for all examples
```

- ```
  print("st[:] is", st[:])        #output is
  Hello World
  ```
  As both index values are not given, it assumed to be a full string.

- ```
  print("st[0:5] is ", st[0:5])  #output is
  Hello
  ```
  Starting from 0th index to 4th index (5 is exclusive), characters will be printed.

- ```
  print("st[0:5:1] is", st[0:5:1])    #output is

  Hello
  ```
  This code also prints characters from 0th to 4th index in the steps of 1. Comparing this example with previous example, we can make out that when the stride value is 1, it is optional to mention.

- ```
  print("st[3:8] is ", st[3:8]) #output is
  lo Wo
  ```
  Starting from 3rd index to 7th index (8 is exclusive), characters will be printed.

- ```
  print("st[7:] is ", st[7:])    #output is
  orld
  ```
  Starting from 7th index to till the end of string, characters will be printed.

- ```
  print(st[::2])       #output is
  HloWrd
  ```

  This example uses stride value as 2. So, starting from first character, every alternative character (char+2) will be printed.

- ```
  print("st[4:4] is ", st[4:4]) #gives empty string
  ```

  Here, st[4:4] indicates, slicing should start from 4th character and end with (4- 1)=3rd character, which is not possible. Hence the output would be an empty string.

- ```
  print(st[3:8:2])          #output is
  l o
  ```
  Starting from 3rd character, till 7th character, every alternative index is considered.

- `print(st[1:8:3])` **#output is**

  `eoo`

  Starting from index 1, till 7th index, every 3rd character is extracted here.

- `print(st[-4:-1])` **#output is**

  `orl`

  Refer the diagram of negative indexing given earlier. Excluding the -1st character, all characters at the indices -4, -3 and -2 will be displayed. Observe the role of stride with default value 1 here. That is, it is computed as -4+1 =-3, -3+1=-2 etc.

- `print(st[-1:])` **#output is**

  `d`

  Here, starting index is -1, ending index is not mentioned (means, it takes the index 10) and the stride is default value 1. So, we are trying to print characters from -1 (which is the last character of negative indexing) till 10th character (which is also the last character in positive indexing) in incremental order of 1. Hence, we will get only last character as output.

- `print(st[:-1])` **#output is**

  `Hello Worl`

  Here, starting index is default value 0 and ending is -1 (corresponds to last character in negative indexing). But, in slicing, as last index is excluded always, -1st character is omitted and considered only up to -2nd character.

- `print(st[::])` **#output is**

  `Hello World`

  Here, two colons have used as if stride will be present. But, as we haven't mentioned stride its default value 1 is assumed. Hence this will be a full string.

- `print(st[::-1])` **#output is**

  `dlroW olleH`

  This example shows the power of slicing in Python. Just with proper slicing, we could able to ***reverse the string***. Here, the meaning is *a full string to be extracted in the order of -1*. Hence, the string is printed in the reverse order.

- `print(st[::-2])` **#output is**

  `drWolH`

  Here, the string is printed in the reverse order in steps of -2. That is, every alternative character in the reverse order is printed. Compare this with example (6) given above.

By the above set of examples, one can understand the power of string slicing and of Python script. The slicing is a powerful tool of Python which makes many task simple pertaining to data types like strings, Lists, Tuple, Dictionary etc. (Other types will be discussed in later Modules)

2.3.5 Strings are Immutable

The objects of string class are immutable. That is, once the strings are created (or initialized), they cannot be modified. No character in the string can be edited/deleted/added. Instead, one can create a new string using an existing string by imposing any modification required.

Try to attempt following assignment –

```
>>> st= "Hello World"
>>> st[3]='t'
TypeError: 'str' object does not support item assignment
```

Here, we are trying to change the 4th character (index 3 means, 4th character as the first index is 0) to *t.* The error message clearly states that an assignment of new *item* (a string)is not possible on string object. So, to achieve our requirement, we can create a new string using slices of existing string as below –

```
>>> st= "Hello World"
>>> st1= st[:3]+ 't' + st[4:]
>>> print(st1)
     Helto World          #l is replaced by t in new
     string st1
```

2.3.6 Looping and Counting

Using loops on strings, we can count the frequency of occurrence of a character within another string. The following program demonstrates such a pattern on computation called as a ***counter***. Initially, we accept one string and one character (single letter). Our aim tofind the total number of times the character has appeared in string. A variable *count* is initialized to zero, and incremented each time a character is found. The program is given below –

```
def countChar(st,ch):

    count=0
    for i in st:

        if i==ch:
```

```
            count+=1
            return count

st=input("Enter a string:")
ch=input("Enter a character to be counted:")
c=countChar(st,ch)
print("{0} appeared {1} times in {2}".format(ch,c,st))
```

Sample Output:

Enter a string: hello how are you?

Enter a character to be counted: h

h appeared 2 times in hello how are you?

2.3.7 The *in* Operator

The ***in*** operator of Python is a Boolean operator which takes two string operands. It returns True, if the first operand appears in second operand, otherwise returns False. For example,

```
>>> 'el' in 'hello'      #el is found in hello
True
>>> 'x' in 'hello'       #x is not found in hello
False
```

2.3.8 String Comparison

Basic comparison operators like < (less than), > (greater than), == (equals) etc. can be applied on string objects. Such comparison results in a Boolean value True or False. Internally, such comparison happens using ASCII codes of respective characters. Consider following examples –

Ex1.
```
st= "hello"
if st== 'hello':
     print('same')
```

Output is `same`. As the value contained in `st` and `hello` both are same, the equality results in True.

Ex2.
```
st= "hello"
if st<= 'Hello':
     print('lesser')
else:
     print('greater')
```

Output is `greater`. The ASCII value of `h` is greater than ASCII value of `H`. Hence, `hello` is greater than `Hello`.

NOTE: A programmer must know ASCII values of some of the basic characters. Here are few –

A – Z	: 65 – 90
a – z	: 97 – 122
0 – 9	: 48 – 57
Space	32
Enter Key	13

2.3.9 String Methods

String is basically a ***class*** in Python. When we create a string in our program, an ***object*** of that class will be created. A class is a collection of member variables and member methods (or functions). When we create an object of a particular class, the object can use all the members (both variables and methods) of that class. Python provides a rich set of built-in classes for various purposes. Each class is enriched with a useful set of utility functions and variables that can be used by a Programmer. A programmer can create a class based on his/her requirement, which are known as user-defined classes.

The built-in set of members of any class can be accessed using the dot operator as shown–

```
objName.memberMethod(arguments)
```

The dot operator always binds the member's name with the respective object name. This is very essential because, there is a chance that more than one class has members with same name. To avoid that conflict, almost all Object-oriented languages have been designed with this common syntax of using dot operator. (Detailed discussion on classes and objects will be done in later Modules.)

Python provides a function (or method) ***dir*** to list all the variables and methods of a particular class object. Observe the following statements –

```
>>> s="hello"        #string object is created with the name s
>>> type(s)          #checking type of s
<class 'str'>        #s is object of type class str
>>> dir(s)      #display all methods and variables of object s
```

```
['__add__', '__class__', '__contains__', '__delattr__', '
dir__','__doc__', '__eq__', '__format__', '__ge__', '
getattribute__','__getitem__', '__getnewargs__', '__gt__', '
hash__', '__init__','__init_subclass__', '__iter__', '__le
', '__len__', '__lt__','__mod__', '__mul__', '__ne__',
'__new__', '__reduce__','__reduce_ex__', '__repr__', '__rmod
', '__rmul__', '__setattr__','_sizeof_', '_str__', '
subclasshook__', 'capitalize','casefold', 'center', 'count',
'encode', 'endswith', 'expandtabs', 'find', 'format',
'format_map', 'index', 'isalnum', 'isalpha', 'isdecimal',
'isdigit', 'isidentifier', 'islower',
'isnumeric','isprintable', 'isspace', 'istitle', 'isupper',
'join', 'ljust','lower', 'lstrip', 'maketrans', 'partition',
'replace', 'rfind',
'rindex', 'rjust', 'rpartition', 'rsplit', 'rstrip', 'split',
'splitlines', 'startswith', 'strip', 'swapcase', 'title',
'translate', 'upper', 'zfill']
```

Students need not remember the above list !!

Note that, the above set of variables and methods are common for any object of string class that we create. Each built-in method has a predefined set of arguments and return type. To know the usage, working and behavior of any built-in method, one can use the command ***help***. For example, if we would like to know what is the purpose of `islower()` function (refer above list to check its existence!!), how it behaves etc, we can use the statement –

```
>>> help(str.islower)
Help on method_descriptor:

islower(...)
    S.islower() -> bool

    Return True if all cased characters in S are lowercase
andthere is at least one cased character in S, False otherwise.
```

This is built-in help-service provided by Python. Observe the `className.memberName`

format while using ***help***.

The methods are usually called using the object name. This is known as ***method invocation.*** We say that a method is invoked using an object.

Now, we will discuss some of the important methods of string class.

- **capitalize(s) :** This function takes one string argument *s* and returns a capitalized version of that string. That is, the first character of *s* is converted to upper case, and all other characters to lowercase. Observe the examples given below –

Ex1.
```
>>> s="hello"
>>> s1=str.capitalize(s)
>>> print(s1)
     Hello   #1st character is changed to uppercase
```

Ex2.
```
>>> s="hello World"
>>> s1=str.capitalize(s)
>>> print(s1)
     Hello world
```

Observe in Ex2 that the first character is converted to uppercase, and an in-between uppercase letter W of the original string is converted to lowercase.

- **s.upper():** This function returns a copy of a string s to uppercase. As strings are immutable, the original string s will remain same.

```
>>> st= "hello"
>>> st1=st.upper()
>>> print(st1)
     'HELLO'
>>> print( st)    #no change in original string'hello'
```

- **s.lower():** This method is used to convert a string s to lowercase. It returns a copy of original string after conversion, and original string is intact.

```
>>> st='HELLO'
>>> st1=st.lower()
>>> print(st1)hello
>>> print(st)       #no change in original string
     HELLO
```

- **s.find(s1) :** The `find()` function is used to search for a substring s1 in the string s. If found, the index position of first occurrence of s1 in s, is returned. If s1 is not found in s, then -1 is returned.

```
>>> st='hello'
```

```
>>> i=st.find('l')
>>> print(i)                    #output is
2
>>> i=st.find('lo')
>>> print(i)                    #output is
3
>>> print(st.find('x'))         #output is
-1
```

The `find()` function can take one more form with two additional arguments viz. startand end positions for search.

```
>>> st="calender of Feb. cal of march"
>>> i= st.find('cal')
>>> print(i)                    #output is
0
```

Here, the substring `'cal'` is found in the very first position of `st`, hence the result is 0.

```
>>> i=st.find('cal',10,20)
>>> print(i)                    #output is
17
```

Here, the substring `cal` is searched in the string `st` between 10th and 20th position and hence the result is 17.

```
>>> i=st.find('cal',10,15)
>>> print(i)                    #ouput is
-1
```

In this example, the substring `'cal'` has not appeared between 10th and 15thcharacter of st. Hence, the result is -1.

- **s.strip():** Returns a copy of string *s* by removing leading and trailing white spaces.

```
>>> st="     hello world    "
>>> st1 = st.strip()
>>> print(st1)
     hello world
```

The *strip()* function can be used with an argument *chars*, so that specified *chars* are removed from beginning or ending of *s* as shown below –

```
>>> st="###Hello##"
>>> st1=st.strip('#')
```

```
>>> print(st1)            #all hash symbols are removed
     Hello
```

We can give more than one character for removal as shown below –

```
>>> st="Hello world"
>>> st.strip("Hld")
ello wor
```

- **S.startswith(prefix, start, end):** This function has 3 arguments of which *start* and *end* are option. This function returns True if S starts with the specified *prefix*, False otherwise.

```
>>> st="hello world"
>>> st.startswith("he")       #returns
True
```

When *start* argument is provided, the search begins from that position and returns True or False based on search result.

```
>>> st="hello world"
>>> st.startswith("w",6)#True because w is at 6th position
```

When both *start* and *end* arguments are given, search begins at *start* and ends at *end*.

```
>>> st="xyz abc pqr ab mn gh‟
>>> st.startswith("pqr ab mn",8,12)   #returns False
False
>>> st.startswith("pqr ab mn",8,18)     #returns True

True
```

The `startswith()` function requires case of the alphabet to match. So, when we are not sure about the case of the argument, we can convert it to either upper case or lowercase and then use `startswith()` function as below –

```
>>> st="Hello"
>>> st.startswith("he")            #returns False
False
>>> st.lower().startswith("he")          #returns True
True
```

- **S.count(s1, start, end):** The `count()` function takes three arguments – *string, starting position* and *ending position*. This function returns the number of non-overlapping occurrences of substring s1 in string S in the range of *start* and *end*.

```
>>> st="hello how are you? how about you?"
>>> st.count('h')              #output is
    3
>>> st.count('how')            #output is
    2
>>> st.count('how',3,10)       #output is
    1
```

because of range given.

There are many more built-in methods for string class. Students are advised to explore more for further study.

2.3.10 Parsing Strings

Sometimes, we may want to search for a substring matching certain criteria. For example, finding domain names from email-Ids in the list of messages is a useful task in some projects. Consider a string below and we are interested in extracting only the domain name.

"From manojkumarsb@*bgsit.ac.in* *Wed Feb 03 09:14:16 2023"*

Now, our aim is to extract only *ieee.org*, which is the domain name. We can think of logic as–

- Identify the position of @, because all domain names in email IDs will be after thesymbol @
- Identify a white space which appears after @ symbol, because that will be the end of domain name.
- Extract the substring between @ and white-space.

The concept of string slicing and *find()* function will be useful here. Consider the code given below –

```
st="From manojkumarsb@bgsit.ac.in Wed Feb 03 09:14:16 2023"
atpos=st.find('@')                  #finds the position of @

print('Position of @ is', atpos)

spacePos=st.find('  ', atpos)#position of white-space after @

print('Position of space after @ is', spacePos)
```

```
host=st[atpos+1:spacePos]#slicing from @ till white-space
print(host)
```

Execute above program to get the output as *bgsit.ac.in*. One can apply this logic in a loop, when our string contains series of email IDs, and we may want to extract all those mail IDs.

2.3.11 Format Operator

The format operator, % allows us to construct strings, replacing parts of the strings with the data stored in variables. The first operand is the format string, which contains one or more *format sequences* that specify how the second operand is formatted. The result is a string.

```
>>> sum=20
>>> '%d' %sum
     '20'           #string '20', but not integer 20
```

Note that, when applied on both integer operands, the % symbol acts as a modulus operator. When the first operand is a string, then it is a format operator. Consider few examples illustrating usage of format operator.

Ex1.
```
>>> "The sum value %d is originally integer"%sum'The sum
     value 20 is originally integer'
```

Ex2.
```
>>> '%d %f %s'%(3,0.5,'hello')
     '3 0.500000 hello'
```

Ex3.
```
>>> '%d %g %s'%(3,0.5,'hello')
     '3 0.5 hello'
```

Ex4.
```
>>> '%d'% 'hello'
TypeError: %d format: a number is required, not str
```

Ex5.
```
>>> '%d %d %d'%(2,5)
TypeError: not enough arguments for format string
```