Lecture 2.1
Fundamental Concepts

Python Variables

A variable is a named location used to store data in the memory. It is helpful to think of variables as a container that holds data that can be changed later in the program. For example,

```
number = 10
```

Here, we have created a variable named *number*. We have assigned the value 10 to the variable.

You can think of variables as a bag to store books in it and that book can be replaced at any time.

```
number = 10
number = 1.1
```

Initially, the value of *number* was 10. Later, it was changed to 1.1.

Note: In Python, we don't actually assign values to the variables. Instead, Python gives the reference of the object(value) to the variable.

Assigning values to Variables in Python

As you can see from the above example, you can use the assignment operator = to assign a value to a variable.

Example 1: Declaring and assigning value to a variable

```
website = "apple.com"
print(website)
```

Output

```
apple.com
```

In the above program, we assigned a value apple.com to the variable *website*. Then, we printed out the value assigned to *website* i.e. apple.com

Note: Python is a type-inferred language, so you don't have to explicitly define the variable type. It automatically knows that apple.com is a string and declares the *website* variable as a string.

Example 2: Changing the value of a variable

```
website = "apple.com"
print(website)

# assigning a new variable to website
website = "programiz.com"

print(website)
```

Output

```
apple.com
programiz.com
```

In the above program, we have assigned apple.com to the *website* variable initially. Then, the value is changed to programiz.com.

Example 3: Assigning multiple values to multiple variables

```
a, b, c = 5, 3.2, "Hello"

print (a)
print (b)
print (c)
```

If we want to assign the same value to multiple variables at once, we can do this as:

```
x = y = z = "same"

print (x)
print (y)
print (z)
```

The second program assigns the same string to all the three variables *x*, *y* and *z*.

Constants

A constant is a type of variable whose value cannot be changed. It is helpful to think of constants as containers that hold information which cannot be changed later.

You can think of constants as a bag to store some books which cannot be replaced once placed inside the bag.

Assigning value to constant in Python

In Python, constants are usually declared and assigned in a module. Here, the module is a new file containing variables, functions, etc which is imported to the main file. Inside the module, constants are written in all capital letters and underscores separating the words.

Example 3: Declaring and assigning value to a constant

Create a **constant.py**:

```
PI = 3.14
GRAVITY = 9.8
```

Create a **main.py**:

```
import constant

print(constant.PI)
print(constant.GRAVITY)
```

Output

```
3.14
9.8
```

In the above program, we create a **constant.py** module file. Then, we assign the constant value to *PI* and *GRAVITY*. After that, we create a **main.py** file and import the constant module. Finally, we print the constant value.

Note: In reality, we don't use constants in Python. Naming them in all capital letters is a convention to separate them from variables, however, it does not actually prevent reassignment.

Rules and Naming Convention for Variables and constants

1. Constant and variable names should have a combination of letters in lowercase (a to z) or uppercase (**A to Z**) or digits (**0 to 9**) or an underscore (_). For example:
2. snake_case
3. MACRO_CASE
4. camelCase
   CapWords

5. Create a name that makes sense. For example, *vowel* makes more sense than *v*.
6. If you want to create a variable name having two words, use underscore to separate them. For example:
7. my_name
   current_salary

8. Use capital letters possible to declare a constant. For example:

9. PI
10. G
11. MASS
12. SPEED_OF_LIGHT
    TEMP

13. Never use special symbols like !, @, #, $, %, etc.
14. Don't start a variable name with a digit.

Literals

Literal is a raw data given in a variable or constant. In Python, there are various types of literals they are as follows:

Numeric Literals

Numeric Literals are immutable (unchangeable). Numeric literals can belong to 3 different numerical types: Integer, Float, and Complex.

Example 4: How to use Numeric literals in Python?

```
a = 0b1010 #Binary Literals
b = 100 #Decimal Literal
c = 0o310 #Octal Literal
d = 0x12c #Hexadecimal Literal

#Float Literal
float_1 = 10.5
float_2 = 1.5e2

#Complex Literal
x = 3.14j

print(a, b, c, d)
print(float_1, float_2)
print(x, x.imag, x.real)
```

Output

```
10 100 200 300
10.5 150.0
3.14j 3.14 0.0
```

In the above program,

- We assigned integer literals into different variables. Here, *a* is binary literal, *b* is a decimal literal, *c* is an octal literal and *d* is a hexadecimal literal.
- When we print the variables, all the literals are converted into decimal values.

- 10.5 and 1.5e2 are floating-point literals. 1.5e2 is expressed with exponential and is equivalent to $1.5 * 10^2$.
- We assigned a complex literal i.e 3.14j in variable *x*. Then we use **imaginary** literal (x.imag) and **real** literal (x.real) to create imaginary and real parts of complex numbers.

To learn more about Numeric Literals, refer to Python Numbers.

String literals

A string literal is a sequence of characters surrounded by quotes. We can use both single, double, or triple quotes for a string. And, a character literal is a single character surrounded by single or double quotes.

Example 7: How to use string literals in Python?

```
strings = "This is Python"
char = "C"
multiline_str = """This is a multiline string with more than one line code."""
unicode = u"\u00dcnic\u00f6de"
raw_str = r"raw \n string"

print(strings)
print(char)
print(multiline_str)
print(unicode)
print(raw_str)
```

Output

```
This is Python
C
This is a multiline string with more than one line code.
Ünicöde
raw \n string
```

In the above program, This is Python is a string literal and C is a character literal.

The value in triple-quotes """ assigned to the *multiline_str* is a multi-line string literal.

The string u"\u00dcnic\u00f6de" is a Unicode literal which supports characters other than English. In this case, \u00dc represents Ü and \u00f6 represents ö.

r"raw \n string" is a raw string literal.

Lecture 2.2
Fundamental Concepts

Data types in Python

Every value in Python has a datatype. Since everything is an object in Python programming, data types are actually classes and variables are instance (object) of these classes.

There are various data types in Python. Some of the important types are listed below.

Python Numbers

Integers, floating point numbers and complex numbers fall under Python numbers category. They are defined as int, float and complex classes in Python.

We can use the type() function to know which class a variable or a value belongs to. Similarly, the isinstance() function is used to check if an object belongs to a particular class.

```
a = 5
print(a, "is of type", type(a))

a = 2.0
print(a, "is of type", type(a))

a = 1+2j
print(a, "is complex number?", isinstance(1+2j,complex))
```

Output

```
5 is of type <class 'int'>
2.0 is of type <class 'float'>
(1+2j) is complex number? True
```

Integers can be of any length, it is only limited by the memory available.

A floating-point number is accurate up to 15 decimal places. Integer and floating points are separated by decimal points. 1 is an integer, 1.0 is a floating-point number.

Complex numbers are written in the form, x + yj, where *x* is the real part and *y* is the imaginary part. Here are some examples.

```
>>> a = 1234567890123456789
>>> a
1234567890123456789
>>> b = 0.1234567890123456789
>>> b
0.12345678901234568
```

```
>>> c = 1+2j
>>> c
(1+2j)
```

Notice that the float variable *b* got truncated.

Python Type Conversion and Type Casting

Type Conversion

The process of converting the value of one data type (integer, string, float, etc.) to another data type is called type conversion. Python has two types of type conversion.

1. Implicit Type Conversion
2. Explicit Type Conversion

Implicit Type Conversion

In Implicit type conversion, Python automatically converts one data type to another data type. This process doesn't need any user involvement.

Let's see an example where Python promotes the conversion of the lower data type (integer) to the higher data type (float) to avoid data loss.

Example 1: Converting integer to float

```
num_int = 123
num_flo = 1.23

num_new = num_int + num_flo

print("datatype of num_int:",type(num_int))
print("datatype of num_flo:",type(num_flo))

print("Value of num_new:",num_new)
print("datatype of num_new:",type(num_new))
```

When we run the above program, the output will be:

```
datatype of num_int: <class 'int'>
datatype of num_flo: <class 'float'>

Value of num_new: 124.23
datatype of num_new: <class 'float'>
```

In the above program,

- We add two variables *num_int* and *num_flo*, storing the value in *num_new*.
- We will look at the data type of all three objects respectively.
- In the output, we can see the data type of *num_int* is an `integer` while the data type of *num_flo* is a `float`.
- Also, we can see the *num_new* has a `float` data type because Python always converts smaller data types to larger data types to avoid the loss of data.

Now, let's try adding a string and an integer, and see how Python deals with it.

Example 2: Addition of string(higher) data type and integer(lower) datatype

```
num_int = 123
num_str = "456"

print("Data type of num_int:",type(num_int))
print("Data type of num_str:",type(num_str))

print(num_int+num_str)
```

When we run the above program, the output will be:

```
Data type of num_int: <class 'int'>
Data type of num_str: <class 'str'>

Traceback (most recent call last):
  File "python", line 7, in <module>
TypeError: unsupported operand type(s) for +: 'int' and 'str'
```

In the above program,

- We add two variables *num_int* and *num_str*.
- As we can see from the output, we got `TypeError`. Python is not able to use Implicit Conversion in such conditions.
- However, Python has a solution for these types of situations which is known as Explicit Conversion.

Explicit Type Conversion

In Explicit Type Conversion, users convert the data type of an object to required data type. We use the predefined functions like `int()`, `float()`, `str()`, etc to perform explicit type conversion.

This type of conversion is also called typecasting because the user casts (changes) the data type of the objects.

Syntax :

<required_datatype>(expression)

Typecasting can be done by assigning the required data type function to the expression.

Example 3: Addition of string and integer using explicit conversion

```
num_int = 123
num_str = "456"

print("Data type of num_int:",type(num_int))
print("Data type of num_str before Type Casting:",type(num_str))

num_str = int(num_str)
print("Data type of num_str after Type Casting:",type(num_str))

num_sum = num_int + num_str

print("Sum of num_int and num_str:",num_sum)
print("Data type of the sum:",type(num_sum))
```

When we run the above program, the output will be:

```
Data type of num_int: <class 'int'>
Data type of num_str before Type Casting: <class 'str'>

Data type of num_str after Type Casting: <class 'int'>

Sum of num_int and num_str: 579
Data type of the sum: <class 'int'>
```

In the above program,

- We add *num_str* and *num_int* variable.
- We converted *num_str* from string(higher) to integer(lower) type using `int()` function to perform the addition.
- After converting *num_str* to an integer value, Python is able to add these two variables.
- We got the *num_sum* value and data type to be an integer.

Key Points to Remember

1. Type Conversion is the conversion of object from one data type to another data type.
2. Implicit Type Conversion is automatically performed by the Python interpreter.
3. Python avoids the loss of data in Implicit Type Conversion.
4. Explicit Type Conversion is also called Type Casting, the data types of objects are converted using predefined functions by the user.
5. In Type Casting, loss of data may occur as we enforce the object to a specific data type.

Lecture 3.1

Fundamental Concepts

Boolean literals

A Boolean literal can have any of the two values: True or False.

Example 8: How to use boolean literals in Python?

```
x = (1 == True)
y = (1 == False)
a = True + 4
b = False + 10

print("x is", x)
print("y is", y)
print("a:", a)
print("b:", b)
```

Output

```
x is True
y is False
a: 5
b: 10
```

In the above program, we use boolean literal True and False. In Python, True represents the value as 1 and False as 0. The value of *x* is True because 1 is equal to True. And, the value of *y* is False because 1 is not equal to False.

Similarly, we can use the True and False in numeric expressions as the value. The value of *a* is 5 because we add True which has a value of 1 with 4. Similarly, *b* is 10 because we add the False having value of 0 with 10.

Special literals

Python contains one special literal i.e. None. We use it to specify that the field has not been created.

Example 9: How to use special literals in Python?

```
drink = "Available"
food = None

def menu(x):
    if x == drink:
        print(drink)
    else:
        print(food)

menu(drink)
menu(food)
```

Output

```
Available
None
```

In the above program, we define a menu function. Inside menu, when we set the argument as drink then, it displays Available. And, when the argument is food, it displays None.

Literal Collections

There are four different literal collections List literals, Tuple literals, Dict literals, and Set literals.

Example 10: How to use literals collections in Python?

```
fruits = ["apple", "mango", "orange"] #list
numbers = (1, 2, 3) #tuple
alphabets = {'a':'apple', 'b':'ball', 'c':'cat'} #dictionary
vowels = {'a', 'e', 'i' , 'o', 'u'} #set
```

```
print(fruits)
print(numbers)
print(alphabets)
print(vowels)
```

Output

```
['apple', 'mango', 'orange']
(1, 2, 3)
{'a': 'apple', 'b': 'ball', 'c': 'cat'}
{'e', 'a', 'o', 'i', 'u'}
```

In the above program, we created a list of *fruits*, a tuple of *numbers*, a dictionary *dict* having values with keys designated to each value and a set of *vowels*.

Lecture 3.2
Fundamental Concepts

Python Operators

What are operators in python?

Operators are special symbols in Python that carry out arithmetic or logical computation. The value that the operator operates on is called the operand.

For example:

```
>>> 2+3
5
```

Here, `+` is the operator that performs addition. `2` and `3` are the operands and `5` is the output of the operation.

Arithmetic operators

Arithmetic operators are used to perform mathematical operations like addition, subtraction, multiplication, etc.

Operator	Meaning	Example
+	Add two operands or unary plus	x + y+ 2
-	Subtract right operand from the left or unary minus	x - y- 2
*	Multiply two operands	x * y
/	Divide left operand by the right one (always results into float)	x / y
%	Modulus - remainder of the division of left operand by the right	x % y (remainder of x/y)
//	Floor division - division that results into whole number adjusted to the left in the number line	x // y
**	Exponent - left operand raised to the power of right	x**y (x to the power y)

Example 1: Arithmetic operators in Python

```
x = 15
y = 4

# Output: x + y = 19
print('x + y =',x+y)

# Output: x - y = 11
print('x - y =',x-y)

# Output: x * y = 60
print('x * y =',x*y)

# Output: x / y = 3.75
print('x / y =',x/y)

# Output: x // y = 3
print('x // y =',x//y)

# Output: x ** y = 50625
```

```
print('x ** y =',x**y)
```

Output

```
x + y = 19
x - y = 11
x * y = 60
x / y = 3.75
x // y = 3
x ** y = 50625
```

Comparison operators

Comparison operators are used to compare values. It returns either `True` or `False` according to the condition.

Operator	Meaning	Example
>	Greater than - True if left operand is greater than the right	x > y
<	Less than - True if left operand is less than the right	x < y
==	Equal to - True if both operands are equal	x == y
!=	Not equal to - True if operands are not equal	x != y
>=	Greater than or equal to - True if left operand is greater than or equal to the right	x >= y
<=	Less than or equal to - True if left operand is less than or equal to the right	x <= y

Example 2: Comparison operators in Python

```
x = 10
y = 12

# Output: x > y is False
print('x > y is',x>y)

# Output: x < y is True
print('x < y is',x<y)

# Output: x == y is False
print('x == y is',x==y)
```

```
# Output: x != y is True
print('x != y is',x!=y)

# Output: x >= y is False
print('x >= y is',x>=y)

# Output: x <= y is True
print('x <= y is',x<=y)
```

Output

```
x > y is False
x < y is True
x == y is False
x != y is True
x >= y is False
x <= y is True
```

Logical operators

Logical operators are the `and`, `or`, `not` operators.

Operator	Meaning	Example
and	True if both the operands are true	x and y
or	True if either of the operands is true	x or y
not	True if operand is false (complements the operand)	not x

Example 3: Logical Operators in Python

```
x = True
y = False

print('x and y is',x and y)

print('x or y is',x or y)

print('not x is',not x)
```

Output

```
x and y is False
x or y is True
not x is False
```

Here is the truth table for these operators.

Bitwise operators

Bitwise operators act on operands as if they were strings of binary digits. They operate bit by bit, hence the name.

For example, 2 is `10` in binary and 7 is `111`.

In the table below: Let *x* = 10 (`0000 1010` in binary) and *y* = 4 (`0000 0100` in binary)

Operator	Meaning	Example
&	Bitwise AND	x & y = 0 (0000 0000)
|	Bitwise OR	x | y = 14 (0000 1110)
~	Bitwise NOT	~x = -11 (1111 0101)
^	Bitwise XOR	x ^ y = 14 (0000 1110)
>>	Bitwise right shift	x >> 2 = 2 (0000 0010)
<<	Bitwise left shift	x << 2 = 40 (0010 1000)

Assignment operators

Assignment operators are used in Python to assign values to variables.

`a = 5` is a simple assignment operator that assigns the value 5 on the right to the variable *a* on the left.

There are various compound operators in Python like `a += 5` that adds to the variable and later assigns the same. It is equivalent to `a = a + 5`.

Operator	Example	Equivalent to
=	x = 5	x = 5
+=	x += 5	x = x + 5
-=	x -= 5	x = x - 5
*=	x *= 5	x = x * 5

/=	x /= 5	x = x / 5
%=	x %= 5	x = x % 5
//=	x //= 5	x = x // 5
**=	x **= 5	x = x ** 5
&=	x &= 5	x = x & 5
|=	x |= 5	x = x | 5
^=	x ^= 5	x = x ^ 5
>>=	x >>= 5	x = x >> 5
<<=	x <<= 5	x = x << 5

Special operators

Python language offers some special types of operators like the identity operator or the membership operator. They are described below with examples.

Identity operators

`is` and `is not` are the identity operators in Python. They are used to check if two values (or variables) are located on the same part of the memory. Two variables that are equal does not imply that they are identical.

Operator	Meaning	Example
is	True if the operands are identical (refer to the same object)	x is True
is not	True if the operands are not identical (do not refer to the same object)	x is not True

Example 4: Identity operators in Python

```
x1 = 5
y1 = 5
x2 = 'Hello'
y2 = 'Hello'
x3 = [1,2,3]
y3 = [1,2,3]

# Output: False
print(x1 is not y1)
```

```
# Output: True
print(x2 is y2)

# Output: False
print(x3 is y3)
```

Output

```
False
True
False
```

Here, we see that *x1* and *y1* are integers of the same values, so they are equal as well as identical. Same is the case with *x2* and *y2* (strings).

But *x3* and *y3* are lists. They are equal but not identical. It is because the interpreter locates them separately in memory although they are equal.

Membership operators

`in` and `not in` are the membership operators in Python. They are used to test whether a value or variable is found in a sequence (string, list, tuple, set and dictionary).

In a dictionary we can only test for presence of key, not the value.

Operator	Meaning	Example
in	True if value/variable is found in the sequence	5 in x
not in	True if value/variable is not found in the sequence	5 not in x

Example #5: Membership operators in Python

```
x = 'Hello world'
y = {1:'a',2:'b'}

# Output: True
print('H' in x)

# Output: True
print('hello' not in x)

# Output: True
print(1 in y)

# Output: False
print('a' in y)
```

Output

True
True
True
False

Here, `'H'` is in *x* but `'hello'` is not present in *x* (remember, Python is case sensitive). Similarly, `1` is key and `'a'` is the value in dictionary *y*. Hence, `'a' in y` returns `False`.

Lecture 4.1
Python List

There are four collection data types in the Python programming language:

- **List** is a collection which is ordered and changeable. Allows duplicate members.
- **Tuple** is a collection which is ordered and unchangeable. Allows duplicate members.
- **Set** is a collection which is unordered and unindexed. No duplicate members.
- **Dictionary** is a collection which is unordered, changeable and indexed. No duplicate members.

Type	Ordered	Changeable	Indexed	Duplicate Allowed
List	√	√	√	√
Tuple	√	×	√	√
Set	×	√	×	×
Dictionary	×	√	√	×

Python List

List is one of the most frequently used and very versatile data types used in Python.

- A list is a collection which is ordered and changeable.
- Allows duplicate members.

- A list in python can store elements of different data types and its size can grow arbitrarily.

Create a list

In Python programming, a list is created by placing all the items (elements) inside square brackets [], separated by commas.

It can have any number of items and they may be of different types (integer, float, string etc.).

```
# empty list
my_list = []

# list of integers
my_list = [1, 2, 3]

# list with mixed data types
my_list = [1, "Hello", 3.4]
```

A list can also have another list as an item. This is called a nested list.

```
# nested list
my_list = ["mouse", [8, 4, 6], ['a']]
```

Access elements from a list

here are various ways in which we can access the elements of a list.

List Index

We can use the index operator `[]` to access an item in a list. In Python, indices start at 0. So, a list having 5 elements will have an index from 0 to 4.

Trying to access indexes other than these will raise an `IndexError`. The index must be an integer. We can't use float or other types, this will result in `TypeError`.

Nested lists are accessed using nested indexing.

```
# List indexing

my_list = ['p', 'r', 'o', 'b', 'e']

# Output: p
print(my_list[0])
```

```
# Output: o
print(my_list[2])

# Output: e
print(my_list[4])

# Nested List
n_list = ["Happy", [2, 0, 1, 5]]

# Nested indexing
print(n_list[0][1])

print(n_list[1][3])

# Error! Only integer can be used for indexing
print(my_list[4.0])
```

Output

```
p
o
e
a
5
Traceback (most recent call last):
  File "<string>", line 21, in <module>
TypeError: list indices must be integers or slices, not float
```

Negative indexing

Python allows negative indexing for its sequences. The index of -1 refers to the last item, -2 to the second last item and so on.

```
# Negative indexing in lists
my_list = ['p','r','o','b','e']

print(my_list[-1])

print(my_list[-5])
```

When we run the above program, we will get the following output:

```
e
p
```

How to slice lists in Python?

We can access a range of items in a list by using the slicing operator :(colon).

```
# List slicing in Python

my_list = ['p','r','o','g','r','a','m','i','z']

# elements 3rd to 5th
print(my_list[2:5])

# elements beginning to 4th
print(my_list[:-5])

# elements 6th to end
print(my_list[5:])

# elements beginning to end
print(my_list[:])
```

Output

```
['o', 'g', 'r']
['p', 'r', 'o', 'g']
['a', 'm', 'i', 'z']
['p', 'r', 'o', 'g', 'r', 'a', 'm', 'i', 'z']
```

Slicing can be best visualized by considering the index to be between the elements as shown below. So if we want to access a range, we need two indices that will slice that portion from the list.

Other List Operations in Python

List Membership Test

We can test if an item exists in a list or not, using the keyword `in`.

```
my_list = ['p', 'r', 'o', 'b', 'l', 'e', 'm']

# Output: True
print('p' in my_list)

# Output: False
print('a' in my_list)

# Output: True
print('c' not in my_list)
```

Output

```
True
False
```

True

Iterating Through a List

Using a `for` loop we can iterate through each item in a list.

```
for fruit in ['apple','banana','mango']:
    print("I like",fruit)
```

Output

```
I like apple
I like banana
I like mango
```

Lecture 4.2
Python List

How to change or add elements to a list?

Lists are mutable, meaning their elements can be changed unlike string or tuple.

We can use the assignment operator (=) to change an item or a range of items.

```
# Correcting mistake values in a list
odd = [2, 4, 6, 8]

# change the 1st item
odd[0] = 1

print(odd)

# change 2nd to 4th items
odd[1:4] = [3, 5, 7]

print(odd)
```

Output

```
[1, 4, 6, 8]
[1, 3, 5, 7]
```

We can add one item to a list using the append() method or add several items using extend() method.

```
# Appending and Extending lists in Python
```

```
odd = [1, 3, 5]

odd.append(7)

print(odd)

odd.extend([9, 11, 13])

print(odd)
```

Output

```
[1, 3, 5, 7]
[1, 3, 5, 7, 9, 11, 13]
```

We can also use + operator to combine two lists. This is also called concatenation.

The * operator repeats a list for the given number of times.

```
# Concatenating and repeating lists
odd = [1, 3, 5]

print(odd + [9, 7, 5])

print(["re"] * 3)
```

Output

```
[1, 3, 5, 9, 7, 5]
['re', 're', 're']
```

Furthermore, we can insert one item at a desired location by using the method insert() or insert multiple items by squeezing it into an empty slice of a list.

```
# Demonstration of list insert() method
odd = [1, 9]
odd.insert(1,3)

print(odd)

odd[2:2] = [5, 7]

print(odd)
```

Output

```
[1, 3, 9]
[1, 3, 5, 7, 9]
```

How to delete or remove elements from a list?

We can delete one or more items from a list using the keyword del. It can even delete the list entirely.

```
# Deleting list items
my_list = ['p', 'r', 'o', 'b', 'l', 'e', 'm']

# delete one item
del my_list[2]

print(my_list)

# delete multiple items
del my_list[1:5]

print(my_list)

# delete entire list
del my_list

# Error: List not defined
print(my_list)
```

Output

```
['p', 'r', 'b', 'l', 'e', 'm']
['p', 'm']
Traceback (most recent call last):
  File "<string>", line 18, in <module>
NameError: name 'my_list' is not defined
```

We can use remove() method to remove the given item or pop() method to remove an item at the given index.

The pop() method removes and returns the last item if the index is not provided. This helps us implement lists as stacks (first in, last out data structure).

We can also use the clear() method to empty a list.

```
my_list = ['p','r','o','b','l','e','m']
my_list.remove('p')

# Output: ['r', 'o', 'b', 'l', 'e', 'm']
print(my_list)

# Output: 'o'
print(my_list.pop(1))

# Output: ['r', 'b', 'l', 'e', 'm']
```

```
print(my_list)

# Output: 'm'
print(my_list.pop())

# Output: ['r', 'b', 'l', 'e']
print(my_list)

my_list.clear()

# Output: []
print(my_list)
```

Output

```
['r', 'o', 'b', 'l', 'e', 'm']
o
['r', 'b', 'l', 'e', 'm']
m
['r', 'b', 'l', 'e']
[]
```

Finally, we can also delete items in a list by assigning an empty list to a slice of elements.

```
>>> my_list = ['p','r','o','b','l','e','m']
>>> my_list[2:3] = []
>>> my_list
['p', 'r', 'b', 'l', 'e', 'm']
>>> my_list[2:5] = []
>>> my_list
['p', 'r', 'm']
```

Python List Methods

Methods that are available with list objects in Python programming are tabulated below.

They are accessed as list.method(). Some of the methods have already been used above.

Python List Methods
append() - Add an element to the end of the list
extend() - Add all elements of a list to the another list
insert() - Insert an item at the defined index
remove() - Removes an item from the list
pop() - Removes and returns an element at the given index

clear() - Removes all items from the list
index() - Returns the index of the first matched item
count() - Returns the count of the number of items passed as an argument
sort() - Sort items in a list in ascending order
reverse() - Reverse the order of items in the list
copy() - Returns a shallow copy of the list

Some examples of Python list methods:

```
# Python list methods
my_list = [3, 8, 1, 6, 0, 8, 4]

# Output: 1
print(my_list.index(8))

# Output: 2
print(my_list.count(8))

my_list.sort()

# Output: [0, 1, 3, 4, 6, 8, 8]
print(my_list)

my_list.reverse()

# Output: [8, 8, 6, 4, 3, 1, 0]
print(my_list)
```

Output

```
1
2
[0, 1, 3, 4, 6, 8, 8]
[8, 8, 6, 4, 3, 1, 0]
```

Lecture 5.1
Python Tuple

A tuple in Python is similar to a list. The difference between the two is that we cannot change the elements of a tuple once it is assigned whereas we can change the elements of a list.

Creating a Tuple

A tuple is created by placing all the items (elements) inside parentheses (), separated by commas. The parentheses are optional, however, it is a good practice to use them.

A tuple can have any number of items and they may be of different types (integer, float, list, string, etc.).

```
# Different types of tuples

# Empty tuple
my_tuple = ()
print(my_tuple)

# Tuple having integers
my_tuple = (1, 2, 3)
print(my_tuple)

# tuple with mixed datatypes
my_tuple = (1, "Hello", 3.4)
print(my_tuple)

# nested tuple
my_tuple = ("mouse", [8, 4, 6], (1, 2, 3))
print(my_tuple)
```

Output

```
()
(1, 2, 3)
(1, 'Hello', 3.4)
('mouse', [8, 4, 6], (1, 2, 3))
```

A tuple can also be created without using parentheses. This is known as tuple packing.

```
my_tuple = 3, 4.6, "dog"
print(my_tuple)

# tuple unpacking is also possible
a, b, c = my_tuple

print(a)      # 3
print(b)      # 4.6
print(c)      # dog
```

Output

```
(3, 4.6, 'dog')
3
4.6
```

dog

Creating a tuple with one element is a bit tricky.

Having one element within parentheses is not enough. We will need a trailing comma to indicate that it is, in fact, a tuple.

```
my_tuple = ("hello")
print(type(my_tuple))  # <class 'str'>

# Creating a tuple having one element
my_tuple = ("hello",)
print(type(my_tuple))  # <class 'tuple'>

# Parentheses is optional
my_tuple = "hello",
print(type(my_tuple))  # <class 'tuple'>
```

Output

```
<class 'str'>
<class 'tuple'>
<class 'tuple'>
```

Access Tuple Elements

There are various ways in which we can access the elements of a tuple.

1. Indexing

We can use the index operator [] to access an item in a tuple, where the index starts from 0.

So, a tuple having 6 elements will have indices from 0 to 5. Trying to access an index outside of the tuple index range(6,7,... in this example) will raise an IndexError.

The index must be an integer, so we cannot use float or other types. This will result in TypeError.

Likewise, nested tuples are accessed using nested indexing, as shown in the example below.

```
# Accessing tuple elements using indexing
my_tuple = ('p','e','r','m','i','t')

print(my_tuple[0])   # 'p'
print(my_tuple[5])   # 't'

# IndexError: list index out of range
# print(my_tuple[6])
```

```
# Index must be an integer
# TypeError: list indices must be integers, not float
# my_tuple[2.0]

# nested tuple
n_tuple = ("mouse", [8, 4, 6], (1, 2, 3))

# nested index
print(n_tuple[0][3])      # 's'
print(n_tuple[1][1])      # 4
```

Output

```
p
t
s
4
```

---

2. Negative Indexing

Python allows negative indexing for its sequences.

The index of -1 refers to the last item, -2 to the second last item and so on.

```
# Negative indexing for accessing tuple elements
my_tuple = ('p', 'e', 'r', 'm', 'i', 't')

# Output: 't'
print(my_tuple[-1])

# Output: 'p'
print(my_tuple[-6])
```

Output

```
t
p
```

---

3. Slicing

We can access a range of items in a tuple by using the slicing operator colon :.

```
# Accessing tuple elements using slicing
my_tuple = ('p','r','o','g','r','a','m','i','z')

# elements 2nd to 4th
# Output: ('r', 'o', 'g')
```

```
print(my_tuple[1:4])

# elements beginning to 2nd
# Output: ('p', 'r')
print(my_tuple[:-7])

# elements 8th to end
# Output: ('i', 'z')
print(my_tuple[7:])

# elements beginning to end
# Output: ('p', 'r', 'o', 'g', 'r', 'a', 'm', 'i', 'z')
print(my_tuple[:])
```

Output

```
('r', 'o', 'g')
('p', 'r')
('i', 'z')
('p', 'r', 'o', 'g', 'r', 'a', 'm', 'i', 'z')
```

Slicing can be best visualized by considering the index to be between the elements as shown below. So if we want to access a range, we need the index that will slice the portion from the tuple.

Lecture 5.2
Python Tuple

Changing a Tuple

Unlike lists, tuples are immutable.

This means that elements of a tuple cannot be changed once they have been assigned. But, if the element is itself a mutable data type like list, its nested items can be changed.

We can also assign a tuple to different values (reassignment).

```
# Changing tuple values
```

```
my_tuple = (4, 2, 3, [6, 5])


# TypeError: 'tuple' object does not support item assignment
# my_tuple[1] = 9

# However, item of mutable element can be changed
my_tuple[3][0] = 9    # Output: (4, 2, 3, [9, 5])
print(my_tuple)

# Tuples can be reassigned
my_tuple = ('p', 'r', 'o', 'g', 'r', 'a', 'm', 'i', 'z')

# Output: ('p', 'r', 'o', 'g', 'r', 'a', 'm', 'i', 'z')
print(my_tuple)
```

Output

```
(4, 2, 3, [9, 5])
('p', 'r', 'o', 'g', 'r', 'a', 'm', 'i', 'z')
```

We can use `+` operator to combine two tuples. This is called **concatenation**.

We can also **repeat** the elements in a tuple for a given number of times using the `*` operator.

Both `+` and `*` operations result in a new tuple.

```
# Concatenation
# Output: (1, 2, 3, 4, 5, 6)
print((1, 2, 3) + (4, 5, 6))

# Repeat
# Output: ('Repeat', 'Repeat', 'Repeat')
print(("Repeat",) * 3)
```

Output

```
(1, 2, 3, 4, 5, 6)
('Repeat', 'Repeat', 'Repeat')
```

Deleting a Tuple

As discussed above, we cannot change the elements in a tuple. It means that we cannot delete or remove items from a tuple.

Deleting a tuple entirely, however, is possible using the keyword del.

```
# Deleting tuples
my_tuple = ('p', 'r', 'o', 'g', 'r', 'a', 'm', 'i', 'z')

# can't delete items
# TypeError: 'tuple' object doesn't support item deletion
# del my_tuple[3]
```

```
# Can delete an entire tuple
del my_tuple

# NameError: name 'my_tuple' is not defined
print(my_tuple)
```

Output

```
Traceback (most recent call last):
  File "<string>", line 12, in <module>
NameError: name 'my_tuple' is not defined
```

Tuple Methods

Methods that add items or remove items are not available with tuple. Only the following two methods are available.

Some examples of Python tuple methods:

```
my_tuple = ('a', 'p', 'p', 'l', 'e',)

print(my_tuple.count('p'))  # Output: 2
print(my_tuple.index('l'))  # Output: 3
```

Output

```
2
3
```

Other Tuple Operations

1. Tuple Membership Test

We can test if an item exists in a tuple or not, using the keyword `in`.

```
# Membership test in tuple
my_tuple = ('a', 'p', 'p', 'l', 'e',)

# In operation
print('a' in my_tuple)
print('b' in my_tuple)

# Not in operation
print('g' not in my_tuple)
```

Output

```
True
False
True
```

---

2. Iterating Through a Tuple

We can use a `for` loop to iterate through each item in a tuple.

```
# Using a for loop to iterate through a tuple
for name in ('John', 'Kate'):
    print("Hello", name)
```

Output

```
Hello John
Hello Kate
```

Advantages of Tuple over List

Since tuples are quite similar to lists, both of them are used in similar situations. However, there are certain advantages of implementing a tuple over a list. Below listed are some of the main advantages:

- We generally use tuples for heterogeneous (different) data types and lists for homogeneous (similar) data types.
- Since tuples are immutable, iterating through a tuple is faster than with list. So there is a slight performance boost.
- Tuples that contain immutable elements can be used as a key for a dictionary. With lists, this is not possible.
- If you have data that doesn't change, implementing it as tuple will guarantee that it remains write-protected.

SR.NO	LIST	TUPLE
1	Lists are mutable	Tuple are immutable
2	Implication of iterations is Time-consuming	Implication of iterations is comparatively Faster
3	The list is better for performing operations, such as insertion	Tuple data type is appropriate for accessing the elements
4	Lists consume more memory	Tuple consume less memory as compared to the list
5	Lists have several built-in methods	Tuple does no have must built-in methods.
6	The unexpected changes and errors are more likely to occur	In tuple, it is hard to take place.

Lecture 6.1
Python Sets

A set is an unordered collection of items. Every set element is unique (no duplicates) and must be immutable (cannot be changed).

However, a set itself is mutable. We can add or remove items from it.

Sets can also be used to perform mathematical set operations like union, intersection, symmetric difference, etc.

Creating Python Sets

A set is created by placing all the items (elements) inside curly braces `{}`, separated by comma, or by using the built-in `set()` function.

It can have any number of items and they may be of different types (integer, float, tuple, string etc.). But a set cannot have mutable elements like lists, sets or dictionaries as its elements.

Example 1:

```
# Different types of sets in Python
# set of integers
my_set = {1, 2, 3}
print(my_set)
# set of mixed datatypes
my_set = {1.0, "Hello", (1, 2, 3)}
print(my_set)
```

Output

```
{1, 2, 3}
{1.0, (1, 2, 3), 'Hello'}
```

Example 2:

```
# set cannot have duplicates
# Output: {1, 2, 3, 4}
my_set = {1, 2, 3, 4, 3, 2}
print(my_set)
# we can make set from a list
# Output: {1, 2, 3}
```

```
my_set = set([1, 2, 3, 2])
print(my_set)
```

Output

{1, 2, 3, 4}

{1, 2, 3}

Creating an empty set

Empty curly braces `{}` will make an empty dictionary in Python. To make a set without any elements, we use the `set()` function without any argument.

Example 3:

```
# Distinguish set and dictionary while creating empty set
# initialize a with {}
a = {}
# check data type of a
print(type(a))
# initialize a with set()
a = set()
# check data type of a
print(type(a))
```

Output

<class 'dict'>

<class 'set'>

Modifying a set in Python

Sets are mutable. However, since they are unordered, indexing has no meaning.

We cannot access or change an element of a set using indexing or slicing. Set data type does not support it.

We can add a single element using the `add()` method, and multiple elements using the `update()` method. The `update()` method can take tuples, lists, strings or other sets as its argument. In all cases, duplicates are avoided.

Example 4:

```
# initialize my_set
my_set = {1, 3}
```

```
print(my_set)
# if you uncomment line 9,
# you will get an error
# TypeError: 'set' object does not support indexing
# my_set[0]
# add an element
# Output: {1, 2, 3}
my_set.add(2)
print(my_set)
# add multiple elements
# Output: {1, 2, 3, 4}
my_set.update([2, 3, 4])
print(my_set)
# add list and set
# Output: {1, 2, 3, 4, 5, 6, 8}
my_set.update([4, 5], {1, 6, 8})
print(my_set)
```

Output

```
{1, 3}
{1, 2, 3}
{1, 2, 3, 4}
{1, 2, 3, 4, 5, 6, 8}
```

Removing elements from a set

A particular item can be removed from a set using the methods `discard()` and `remove()`. The only difference between the two is that the `discard()` function leaves a set unchanged if the element is not present in the set. On the other hand, the `remove()` function will raise an error in such a condition (if element is not present in the set).

Example 5:

```
# Difference between discard() and remove()
# initialize my_set
my_set = {1, 3, 4, 5, 6}
print(my_set)
```

```
# discard an element
# Output: {1, 3, 5, 6}
my_set.discard(4)
print(my_set)
# remove an element
# Output: {1, 3, 5}
my_set.remove(6)
print(my_set)
# discard an element
# not present in my_set
# Output: {1, 3, 5}
my_set.discard(2)
print(my_set)
# remove an element
# not present in my_set
# you will get an error.
# Output: KeyError
my_set.remove(2)
```

Output

```
{1, 3, 4, 5, 6}
{1, 3, 5, 6}
{1, 3, 5}
{1, 3, 5}
Traceback (most recent call last):
  File "<string>", line 28, in <module>
KeyError: 2
```

Similarly, we can remove and return an item using the `pop()` method.

Since set is an unordered data type, there is no way of determining which item will be popped.

It is completely arbitrary.

We can also remove all the items from a set using the `clear()` method.

Example 6:

```
# initialize my_set
# Output: set of unique elements
my_set = set("HelloWorld")
print(my_set)
# pop an element
# Output: random element
print(my_set.pop())
# pop another element
my_set.pop()
print(my_set)
# clear my_set
# Output: set()
my_set.clear()
print(my_set)
print(my_set)
```

Output

```
{'H', 'l', 'r', 'W', 'o', 'd', 'e'}
H
{'r', 'W', 'o', 'd', 'e'}
set()
```

Lecture 6.2

Python Sets

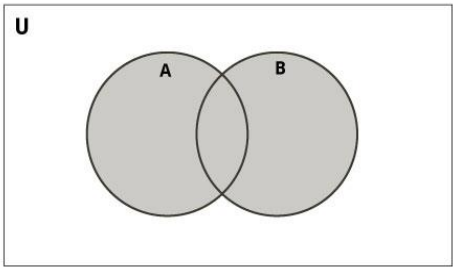
Python Set Operations

Sets can be used to carry out mathematical set operations like union, intersection, difference and symmetric difference. We can do this with operators or methods.

Let us consider the following two sets for the following operations.

```
>>> A = {1, 2, 3, 4, 5}
>>> B = {4, 5, 6, 7, 8}
```

Set Union



Union of *A* and *B* is a set of all elements from both sets.

Union is performed using `|` operator. Same can be accomplished using the `union()` method.

```
# Set union method
# initialize A and B
A = {1, 2, 3, 4, 5}
B = {4, 5, 6, 7, 8}

# use | operator
# Output: {1, 2, 3, 4, 5, 6, 7, 8}
print(A | B)
```

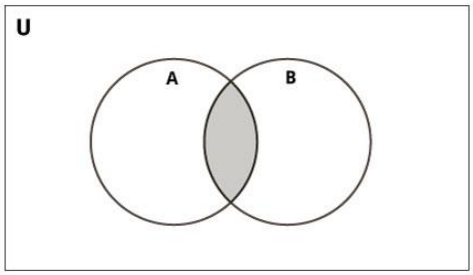
Output

```
{1, 2, 3, 4, 5, 6, 7, 8}
```

Try the following examples on Python shell.

```
# use union function
>>> A.union(B)
{1, 2, 3, 4, 5, 6, 7, 8}

# use union function on B
>>> B.union(A)
{1, 2, 3, 4, 5, 6, 7, 8}
```

Set Intersection



Intersection of *A* and *B* is a set of elements that are common in both the sets.

Intersection is performed using `&` operator. Same can be accomplished using the `intersection()` method.

```
# Intersection of sets
# initialize A and B
A = {1, 2, 3, 4, 5}
B = {4, 5, 6, 7, 8}

# use & operator
# Output: {4, 5}
print(A & B)
```

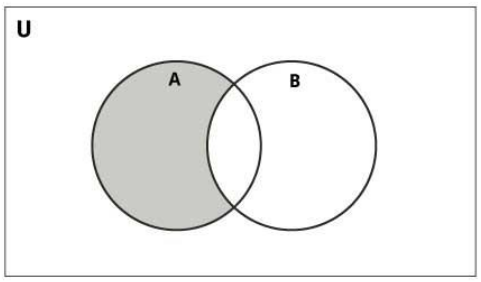
Output

```
{4, 5}
```

Try the following examples on Python shell.

```
# use intersection function on A
>>> A.intersection(B)
{4, 5}

# use intersection function on B
>>> B.intersection(A)
{4, 5}
```

Set Difference



Difference of the set *B* from set *A*(*A* - *B*) is a set of elements that are only in *A* but not in *B*. Similarly, *B* - *A* is a set of elements in *B* but not in *A*.

Difference is performed using – operator. Same can be accomplished using the `difference()` method.

```
# Difference of two sets
# initialize A and B
A = {1, 2, 3, 4, 5}
B = {4, 5, 6, 7, 8}

# use - operator on A
# Output: {1, 2, 3}
print(A - B)
```

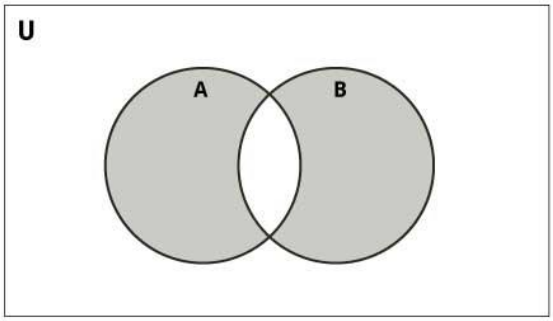
Output

```
{1, 2, 3}
```

Try the following examples on Python shell.

```
# use difference function on A
>>> A.difference(B)
{1, 2, 3}

# use - operator on B
>>> B - A
{8, 6, 7}

# use difference function on B
>>> B.difference(A)
{8, 6, 7}
```

Set Symmetric Difference



Symmetric Difference of *A* and *B* is a set of elements in *A* and *B* but not in both (excluding the intersection).

Symmetric difference is performed using ^ operator. Same can be accomplished using the method `symmetric_difference()`.

```
# Symmetric difference of two sets
# initialize A and B
A = {1, 2, 3, 4, 5}
B = {4, 5, 6, 7, 8}

# use ^ operator
print(A ^ B)
```

Output

```
{1, 2, 3, 6, 7, 8}
```

Try the following examples on Python shell.

```
# use symmetric_difference function on A
>>> A.symmetric_difference(B)
{1, 2, 3, 6, 7, 8}

# use symmetric_difference function on B
>>> B.symmetric_difference(A)
{1, 2, 3, 6, 7, 8}
```

Other Python Set Methods

There are many set methods, some of which we have already used above. Here is a list of all the methods that are available with the set objects:

Method	Description
add()	Adds an element to the set
clear()	Removes all elements from the set
copy()	Returns a copy of the set
difference()	Returns the difference of two or more sets as a new set
difference_update()	Removes all elements of another set from this set
discard()	Removes an element from the set if it is a member. (Do nothing if the element is not in set)
intersection()	Returns the intersection of two sets as a new set
intersection_update()	Updates the set with the intersection of itself and another
isdisjoint()	Returns True if two sets have a null intersection
issubset()	Returns True if another set contains this set
issuperset()	Returns True if this set contains another set
pop()	Removes and returns an arbitrary set element. Raises KeyError if the set is empty
remove()	Removes an element from the set. If the element is not a member, raises a KeyError
symmetric_difference()	Returns the symmetric difference of two sets as a new set
symmetric_difference_update()	Updates a set with the symmetric difference of itself and another
union()	Returns the union of sets in a new set
update()	Updates the set with the union of itself and others

Other Set Operations

Set Membership Test

We can test if an item exists in a set or not, using the `in` keyword.

```
# in keyword in a set
# initialize my_set
my_set = set("apple")

# check if 'a' is present
# Output: True
print('a' in my_set)

# check if 'p' is present
# Output: False
print('p' not in my_set)
```

Output

```
True
False
```

Iterating Through a Set

We can iterate through each item in a set using a `for` loop.

```
>>> for letter in set("apple"):
...     print(letter)
...
a
p
e
l
```

Built-in Functions with Set

Built-in functions like `all()`, `any()`, `enumerate()`, `len()`, `max()`, `min()`, `sorted()`, `sum()` etc. are commonly used with sets to perform different tasks.

Function	Description

all()	Returns True if all elements of the set are true (or if the set is empty).
any()	Returns True if any element of the set is true. If the set is empty, returns False.
enumerate()	Returns an enumerate object. It contains the index and value for all the items of the set as a pair.
len()	Returns the length (the number of items) in the set.
max()	Returns the largest item in the set.
min()	Returns the smallest item in the set.
sorted()	Returns a new sorted list from elements in the set(does not sort the set itself).
sum()	Returns the sum of all elements in the set.

Lecture 7.1

Python Dictionaries

Python dictionary is an unordered collection of items. Each item of a dictionary has a `key/value` pair.

Dictionaries are optimized to retrieve values when the key is known.

Creating Python Dictionary

Creating a dictionary is as simple as placing items inside curly braces `{}` separated by commas.

An item has a `key` and a corresponding `value` that is expressed as a pair (**key: value**).

While the values can be of any data type and can repeat, keys must be of immutable type (string, number or tuple with immutable elements) and must be unique.

```
# empty dictionary
my_dict = {}

# dictionary with integer keys
my_dict = {1: 'apple', 2: 'ball'}

# dictionary with mixed keys
```

```
my_dict = {'name': 'John', 1: [2, 4, 3]}

# using dict()
my_dict = dict({1:'apple', 2:'ball'})

# from sequence having each item as a pair
my_dict = dict([(1,'apple'), (2,'ball')])
```

As you can see from above, we can also create a dictionary using the built-in dict() function.

Accessing Elements from Dictionary

While indexing is used with other data types to access values, a dictionary uses `keys`. Keys can be used either inside square brackets `[]` or with the `get()` method.
If we use the square brackets `[]`, `KeyError` is raised in case a key is not found in the dictionary. On the other hand, the `get()` method returns `None` if the key is not found.

```
# get vs [] for retrieving elements
my_dict = {'name': 'Jack', 'age': 26}

# Output: Jack
print(my_dict['name'])

# Output: 26
print(my_dict.get('age'))

# Trying to access keys which doesn't exist throws error
# Output None
print(my_dict.get('address'))

# KeyError
print(my_dict['address'])
```

Output

```
Jack
```

```
26
None
Traceback (most recent call last):
  File "<string>", line 15, in <module>
    print(my_dict['address'])
KeyError: 'address'
```

Changing and Adding Dictionary elements

Dictionaries are mutable. We can add new items or change the value of existing items using an assignment operator.

If the key is already present, then the existing value gets updated. In case the key is not present, a new (**key: value**) pair is added to the dictionary.

```
# Changing and adding Dictionary Elements
my_dict = {'name': 'Jack', 'age': 26}

# update value
my_dict['age'] = 27

#Output: {'age': 27, 'name': 'Jack'}
print(my_dict)

# add item
my_dict['address'] = 'Downtown'

# Output: {'address': 'Downtown', 'age': 27, 'name': 'Jack'}
print(my_dict)
```

Output

```
{'name': 'Jack', 'age': 27}
{'name': 'Jack', 'age': 27, 'address': 'Downtown'}
```

Lecture 7.2
Python Dictionaries

Removing elements from Dictionary

We can remove a particular item in a dictionary by using the pop() method. This method removes an item with the provided key and returns the value.

The popitem() method can be used to remove and return an arbitrary (key, value) item pair from the dictionary. All the items can be removed at once, using the clear() method.

We can also use the del keyword to remove individual items or the entire dictionary itself.

```
# Removing elements from a dictionary

# create a dictionary
squares = {1: 1, 2: 4, 3: 9, 4: 16, 5: 25}

# remove a particular item, returns its value
# Output: 16
print(squares.pop(4))

# Output: {1: 1, 2: 4, 3: 9, 5: 25}
print(squares)

# remove an arbitrary item, return (key,value)
# Output: (5, 25)
print(squares.popitem())

# Output: {1: 1, 2: 4, 3: 9}
print(squares)

# remove all items
squares.clear()

# Output: {}
print(squares)
```

```
# delete the dictionary itself
del squares

# Throws Error
print(squares)
```

Output

```
16
{1: 1, 2: 4, 3: 9, 5: 25}
(5, 25)
{1: 1, 2: 4, 3: 9}
{}
Traceback (most recent call last):
  File "<string>", line 30, in <module>
    print(squares)
NameError: name 'squares' is not defined
```

Python Dictionary Methods

Methods that are available with a dictionary are tabulated below. Some of them have already been used in the above examples.

Method	Description
clear()	Removes all items from the dictionary.
copy()	Returns a shallow copy of the dictionary.
fromkeys(seq[, v])	Returns a new dictionary with keys from *seq* and value equal to *v* (defaults to None).
get(key[,d])	Returns the value of the *key*. If the *key* does not exist, returns *d* (defaults to None).
items()	Return a new object of the dictionary's items in (key, value) format.
keys()	Returns a new object of the dictionary's keys.

pop(key[,d])	Removes the item with the *key* and returns its value or *d* if *key* is not found. If *d* is not provided and the *key* is not found, it raises KeyError.
popitem()	Removes and returns an arbitrary item (**key, value**). Raises KeyError if the dictionary is empty.
setdefault(key[,d])	Returns the corresponding value if the *key* is in the dictionary. If not, inserts the *key* with a value of *d* and returns *d* (defaults to None).
update([other])	Updates the dictionary with the key/value pairs from *other*, overwriting existing keys.
values()	Returns a new object of the dictionary's values

Here are a few example use cases of these methods.

```
# Dictionary Methods
marks = {}.fromkeys(['Math', 'English', 'Science'], 0)

# Output: {'English': 0, 'Math': 0, 'Science': 0}
print(marks)

for item in marks.items():
    print(item)

# Output: ['English', 'Math', 'Science']
print(list(sorted(marks.keys())))
```

Output

```
{'Math': 0, 'English': 0, 'Science': 0}
('Math', 0)
('English', 0)
('Science', 0)
['English', 'Math', 'Science']
```

Other Dictionary Operations

Dictionary Membership Test

We can test if a `key` is in a dictionary or not using the keyword `in`. Notice that the membership test is only for the `keys` and not for the `values`.

```
# Membership Test for Dictionary Keys
squares = {1: 1, 3: 9, 5: 25, 7: 49, 9: 81}

# Output: True
print(1 in squares)

# Output: True
print(2 not in squares)

# membership tests for key only not value
# Output: False
print(49 in squares)
```

Output

```
True
True
False
```

Iterating Through a Dictionary

We can iterate through each key in a dictionary using a `for` loop.

```
# Iterating through a Dictionary
squares = {1: 1, 3: 9, 5: 25, 7: 49, 9: 81}
for i in squares:
    print(squares[i])
```

Output

```
1
9
```

25

49

81

Dictionary Built-in Functions

Built-in functions like `all()`, `any()`, `len()`, `cmp()`, `sorted()`, etc. are commonly used with dictionaries to perform different tasks.

Function	Description
all()	Return True if all keys of the dictionary are True (or if the dictionary is empty).
any()	Return True if any key of the dictionary is true. If the dictionary is empty, return False.
len()	Return the length (the number of items) in the dictionary.
cmp()	Compares items of two dictionaries. (Not available in Python 3)
sorted()	Return a new sorted list of keys in the dictionary.

Here are some examples that use built-in functions to work with a dictionary.

```
# Dictionary Built-in Functions
squares = {0: 0, 1: 1, 3: 9, 5: 25, 7: 49, 9: 81}

# Output: False
print(all(squares))

# Output: True
print(any(squares))

# Output: 6
print(len(squares))

# Output: [0, 1, 3, 5, 7, 9]
print(sorted(squares))
```

Output

```
False
```

True

6

[0, 1, 3, 5, 7, 9]

Lecture 8.1

Input and Output Operations

- **Lecture Objective:** Discuss some common way of input and output options.
- **Lecture Outcome:** Perform some common way of input and output options.

Taking input in Python

Developers often have a need to interact with users, either to get data or to provide some sort of result. Most programs today use a dialog box as a way of asking the user to provide some type of input. While Python provides us with two inbuilt functions to read the input from the keyboard.

- raw_input (prompt)
- input (prompt)

raw_input ( ) : This function works in older version (like Python 2.x). This function takes exactly what is typed from the keyboard, convert it to string and then return it to the variable in which we want to store. For example – # Python program showing

```
# a use of raw_input()

g = raw_input("Enter your name : ")
print g
```

Output :

Enter your name: sai ram

Sai ram

Here, *g* is a variable which will get the string value, typed by user during the execution of program. Typing of data for the raw_input() function is terminated by enter key. We can use raw_input() to enter numeric data also. In that case we use typecasting.For more details on typecasting refer this.

input ( ) : This function first takes the input from the user and then evaluates the expression, which means Python automatically identifies whether user entered a string or a number or list. If the input provided is not correct then either syntax error or

exception is raised by python. Programs often need to obtain data from the user, usually by way of input from the keyboard. The simplest way to accomplish this in Python is with input().

input([<prompt>])

For example –

```
# Python program showing
# a use of input()

val = input("Enter your value: ")
print(val)
```

Output:

Enter your value:12345

12345

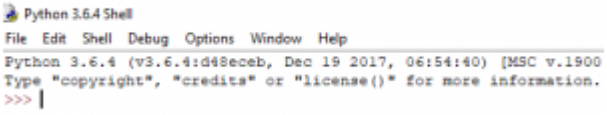
input() pauses program execution to allow the user to type in a line of input from the keyboard. Once the user presses the Enter key, all characters typed are read and returned as a string: input() always returns a string. If you want a numeric type, then you need to convert the string to the appropriate type with the int(), float(), or complex() built-in functions:

How the input function works in Python:

- When input() function executes program flow will be stopped until the user has given an input.
- The text or message display on the output screen to ask a user to enter input value is optional i.e. the prompt, will be printed on the screen is optional.
- Whatever you enter as input, input function convert it into a string. if you enter an integer value still input() function convert it into a string. You need to explicitly convert it into an integer in your code using typecasting.

Taking input from console in Python

What is Console in Python? Console (also called Shell) is basically a command line interpreter that takes input from the user i.e one command at a time and interprets it. If it is error free then it runs the command and gives required output otherwise shows the error message. A Python Console looks like this.



Here we write command and to execute the command just press enter key and your command will be interpreted.
For coding in Python you must know the basics of the console used in Python.

The primary prompt of the python console is the three greater than symbols

```
>>>
```

You are free to write the next command on the shell only when after executing the first command these prompts have appeared. The Python Console accepts command in Python which you write after the prompt.

Accepting Input from Console:

User enters the values in the Console and that value is then used in the program as it was required.
To take input from the user we make use of a built-in function *input()*.

Taking multiple inputs from user in Python

Developer often wants a user to enter multiple values or inputs in one line. In C++/C user can take multiple inputs in one line using scanf but in Python user can take multiple values or inputs in one line by two methods.

- Using split() method
- Using List comprehension

Using split() method :
This function helps in getting a multiple inputs from user . It breaks the given input by the specified separator. If separator is not provided then any white space is a separator. Generally, user use a split() method to split a Python string but one can used it in taking multiple input.

Syntax :

```
input().split(separator, maxsplit)
```

Using List comprehension :
List comprehension is an elegant way to define and create list in Python. We can create lists just like mathematical statements in one line only. It is also used in getting multiple inputs from a user.

Python | Output using print() function

The simplest way to produce output is using the print() function where you can pass zero or more expressions separated by commas. This function converts the expressions you pass into a string before writing to the screen.

Syntax: print(value(s), sep= ' ', end = '\n', file=file, flush=flush)
Parameters:
value(s) : Any value, and as many as you like. Will be converted to string before printed
sep='separator' : (Optional) Specify how to separate the objects, if there is more than one.Default :' '
end='end': (Optional) Specify what to print at the end.Default : '\n'
file : (Optional) An object with a write method. Default :sys.stdout
flush : (Optional) A Boolean, specifying if the output is flushed (True) or buffered (False). Default: False
Returns: It returns output to the screen.
Example:

```
# Python 3.x program showing
# how to print data on
# a screen

# One object is passed
print("REVA University")

x = 5
# Two objects are passed
print("x =", x)

# code for disabling the softspace feature
print('G', 'F', 'G', sep ='')

# using end argument
print("Python", end = '@')
print("Programming")
```

Output:

```
REVA University

x = 5

GFG

Python@Programming
```

There are several ways to present the output of a program, data can be printed in a human-readable form, or written to a file for future use. Sometimes user often wants more control the formatting of output than simply printing space-separated values. There are several ways to format output.

- To use formatted string literals, begin a string with f or F before the opening quotation mark or triple quotation mark.
- The str.format() method of strings help a user to get a fancier Output
- User can do all the string handling by using string slicing and concatenation operations to create any layout that user wants. The string type has some methods that perform useful operations for padding strings to a given column width.
  - Formatting output using String modulo operator(%) : The % operator can also be used for string formatting. It interprets the left argument much like a printf()-style format string to be applied to the right argument. In Python, there is no printf() function but the functionality of the ancient printf is contained in Python. To this purpose, the modulo operator % is overloaded by the string class to perform string formatting. Therefore, it is often called string modulo (or sometimes even called modulus) operator. String modulo operator (%) is still available in Python(3.x) and user is using it widely. But nowadays the old style of formatting is removed from the language.

```
# print integer and float value
print("Geeks : % 2d, Portal : % 5.2f" %(1, 05.333))

# print integer value
print("Total students : % 3d, Boys : % 2d" %(240, 120))

# print octal value
print("% 7.3o"% (25))

# print exponential value
print("% 10.3E"% (356.08977))
```

Output :

```
Geeks :  1, Portal : 5.33
Total students : 240, Boys : 120

 031
```

- 3.561E+02

Formatting output using format method:

The format() method was added in Python(2.6). Format method of strings requires more manual effort. User use {} to mark where a variable will be substituted and can provide detailed formatting directives, but user also needs to provide the information to be formatted. This method lets us concatenate elements within an output through positional formatting. For Example –

```
# using format() method

print('I love {} for "{}!"'.format('Geeks', 'Geeks'))

# using format() method and refering
# a position of the object
print('{0} and {1}'.format('Geeks', 'Portal'))
```

```
print('{1} and {0}'.format('Geeks', 'Portal'))
```

Output :

```
I love Geeks for "Geeks!"
Geeks and Portal
Portal and Geeks
```

Lecture 8.2

Python Conditions

Python Indentation:

- Indentation refers to the spaces at the beginning of a code line.
- Where in other programming languages the indentation in code is for readability only, the indentation in Python is very important.
- Python uses indentation to indicate a block of code.

Python Conditions and If statements

Python supports the usual logical conditions from mathematics:

- Equals: `a == b`
- Not Equals: `a != b`
- Less than: `a < b`
- Less than or equal to: `a <= b`
- Greater than: `a > b`
- Greater than or equal to: `a >= b`

These conditions can be used in several ways, most commonly in "if statements" and loops.

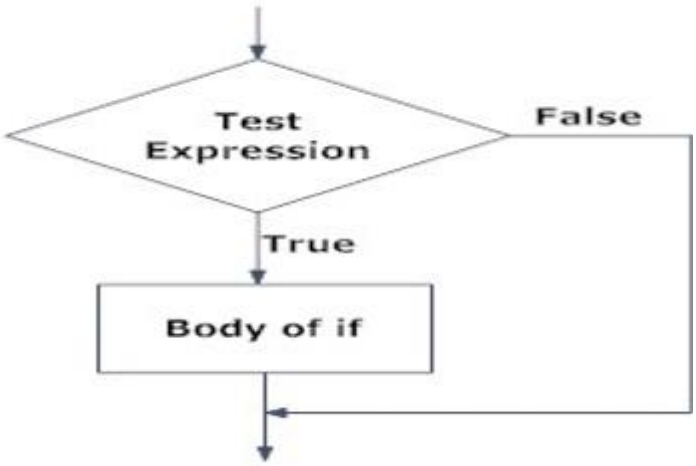
An "if statement" is written by using the `if` keyword.

Example

If statement:

```
a = 33
b = 200
if b > a:
  print("b is greater than a")
```

In this example we use two variables, a and b, which are used as part of the if statement to test whether b is greater than a. As a is 33, and b is 200, we know that 200 is greater than 33, and so we print to screen that "b is greater than a".



Example

If statement, without indentation (will raise an error):

```
a = 33
b = 200
if b > a:
print("b is greater than a") # you will get an error
```

Elif

The elif keyword is pythons way of saying "if the previous conditions were not true, then try this condition".

Example

```
a = 33
b = 33
if b > a:
  print("b is greater than a")
elif a == b:
  print("a and b are equal")
```

In this example a is equal to b, so the first condition is not true, but the elif condition is true, so we print to screen that "a and b are equal".

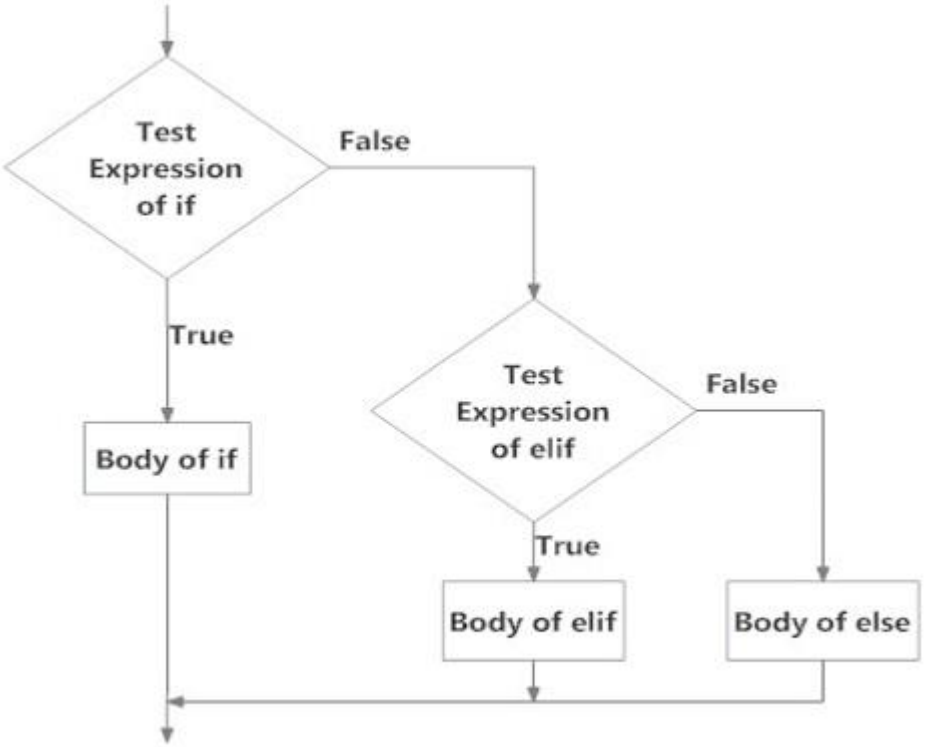
Else

The else keyword catches anything which isn't caught by the preceding conditions.

Example

```
a = 200
b = 33
if b > a:
  print("b is greater than a")
elif a == b:
  print("a and b are equal")
else:
  print("a is greater than b")
```

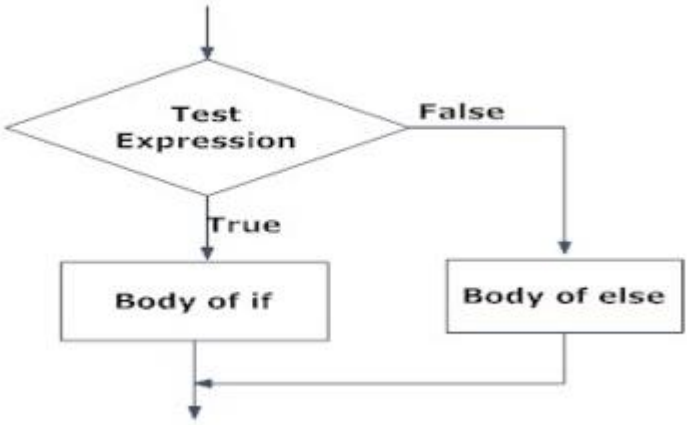
In this example a is greater than b, so the first condition is not true, also the elif condition is not true, so we go to the else condition and print to screen that "a is greater than b".



You can also have an else without the elif:

Example

```
a = 200
b = 33
if b > a:
  print("b is greater than a")
else:
  print("b is not greater than a")
```



Short Hand If

If you have only one statement to execute, you can put it on the same line as the if statement.

Example

One line if statement:

if a > b: print("a is greater than b")

Short Hand If ... Else

If you have only one statement to execute, one for if, and one for else, you can put it all on the same line:

Example

One line if else statement:

```
a = 2
b = 330
print("A") if a > b else print("B")
```

This technique is known as **Ternary Operators**, or **Conditional Expressions**.

You can also have multiple else statements on the same line:

Example

One line if else statement, with 3 conditions:

```
a = 330
b = 330
print("A") if a > b else print("=") if a == b else print("B")
```

And

The and keyword is a logical operator, and is used to combine conditional statements:

Example

Test if a is greater than b, AND if c is greater than a:

```
a = 200
b = 33
c = 500
if a > b and c > a:
  print("Both conditions are True")
```

Or

The or keyword is a logical operator, and is used to combine conditional statements:

Example

Test if a is greater than b, OR if a is greater than c:

```
a = 200
b = 33
c = 500
if a > b or a > c:
  print("At least one of the conditions is True")
```

Nested If

You can have if statements inside if statements, this is called *nested* if statements.

Example

```
x = 41

if x > 10:
  print("Above ten,")
  if x > 20:
    print("and also above 20!")
  else:
    print("but not above 20.")
```

The pass Statement

if statements cannot be empty, but if you for some reason have an if statement with no content, put in the pass statement to avoid getting an error.

Example

```
a = 33
b = 200

if b > a:
  pass
```

Lecture 9.1

Python Loops

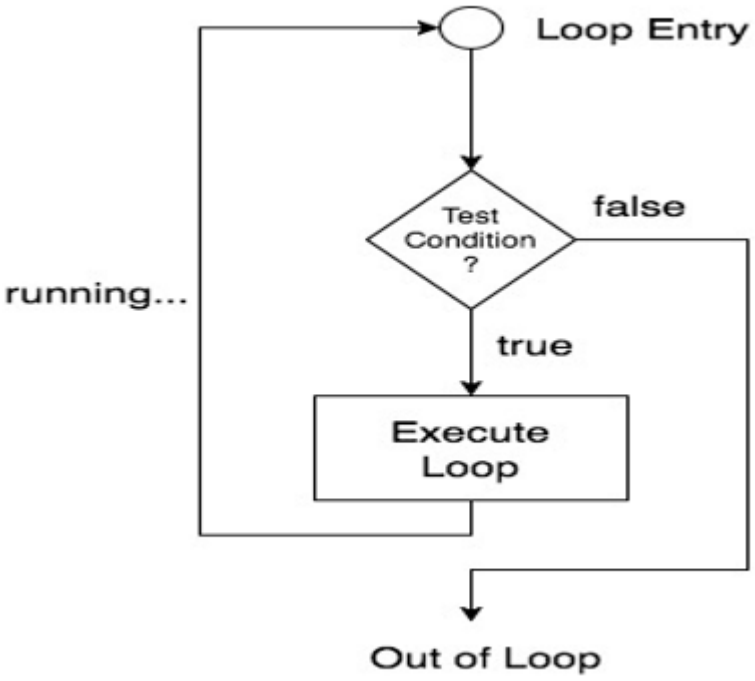
- **Lecture Objective:** Discuss some common way of looping options in Python.
- **Lecture Outcome**: Perform some common way of looping options in Python.

Python Loops

In general, statements are executed sequentially: The first statement in a function is executed first, followed by the second, and so on. There may be a situation when you need to execute a block of code several number of times.

Programming languages provide various control structures that allow for more complicated execution paths.

A loop statement allows us to execute a statement or group of statements multiple times.



Python programming language provides following types of loops to handle looping requirements.

Sr.No.	Loop Type & Description
1	**while loop** Repeats a statement or group of statements while a given condition is TRUE. It tests the condition before executing the loop body.
2	**for loop** Executes a sequence of statements multiple times and abbreviates the code that manages the loop variable.
3	**nested loops** You can use one or more loop inside any another while, for or do..while loop.

Python While Loops

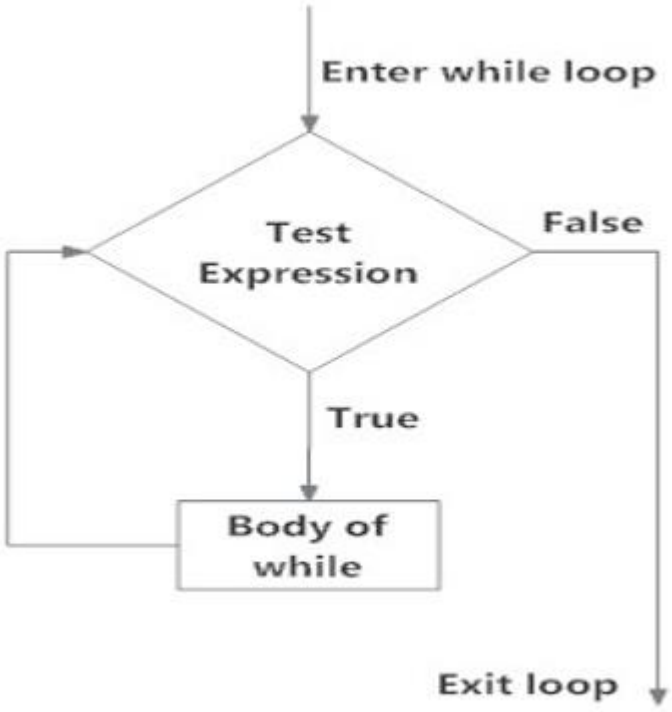
Python Loops

Python has two primitive loop commands:

- while loops
- for loops

The while Loop

With the while loop we can execute a set of statements as long as a condition is true.



Example

Print i as long as i is less than 6:

```
i = 1
while i < 6:
  print(i)
  i += 1
```

The while loop requires relevant variables to be ready, in this example we need to define an indexing variable, i, which we set to 1.

The else Statement

With the else statement we can run a block of code once when the condition no longer is true:

Example

Print a message once the condition is false:

```
i = 1
while i < 6:
  print(i)
  i += 1
else:
  print("i is no longer less than 6")
```

Python For Loops

A for loop is used for iterating over a sequence (that is either a list, a tuple, a dictionary, a set, or a string).

This is less like the for keyword in other programming languages, and works more like an iterator method as found in other object-orientated programming languages.

With the for loop we can execute a set of statements, once for each item in a list, tuple, set etc.

Example

Print each fruit in a fruit list:

```
fruits = ["apple", "banana", "cherry"]
for x in fruits:
  print(x)
```

The for loop does not require an indexing variable to set beforehand.

Looping Through a String

Even strings are iterable objects, they contain a sequence of characters:

Example

Loop through the letters in the word "banana":

```
for x in "banana":
  print(x)
```

The range() Function

To loop through a set of code a specified number of times, we can use the range() function,

The range() function returns a sequence of numbers, starting from 0 by default, and increments by 1 (by default), and ends at a specified number.

Example

Using the range() function:

```
for x in range(6):
  print(x)
```

Note that `range(6)` is not the values of 0 to 6, but the values 0 to 5.

The `range()` function defaults to 0 as a starting value, however it is possible to specify the starting value by adding a parameter: `range(2, 6)`, which means values from 2 to 6 (but not including 6):

Example

Using the start parameter:

```
for x in range(2, 6):
  print(x)
```

The `range()` function defaults to increment the sequence by 1, however it is possible to specify the increment value by adding a third parameter: `range(2, 30, 3)`:

Example

Increment the sequence with 3 (default is 1):

```
for x in range(2, 30, 3):
  print(x)
```

Else in For Loop

The `else` keyword in a `for` loop specifies a block of code to be executed when the loop is finished:

Example

Print all numbers from 0 to 5, and print a message when the loop has ended:

```
for x in range(6):
  print(x)
else:
  print("Finally finished!")
```

Nested Loops

A nested loop is a loop inside a loop.

The "inner loop" will be executed one time for each iteration of the "outer loop":

Example

Print each adjective for every fruit:

```
adj = ["red", "big", "tasty"]
fruits = ["apple", "banana", "cherry"]

for x in adj:
  for y in fruits:
    print(x, y)
```

Lecture 9.2

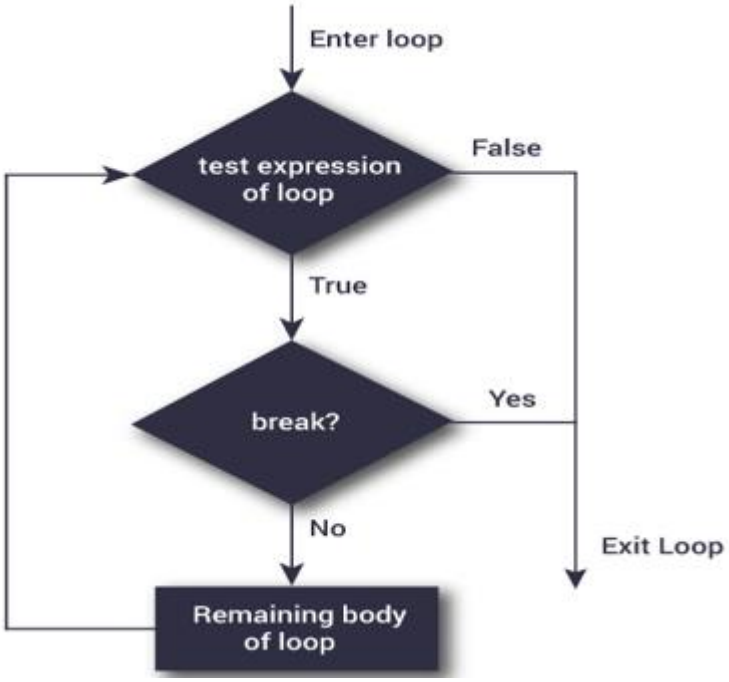
Loop Control Statements

Types

1. break
2. continue
3. pass

The break Statement

With the break statement we can stop the loop even if the while condition is true:



Example

Exit the loop when i is 3:

```
i = 1
while i < 6:
  print(i)
```

```
if i == 3:
  break
i += 1
```

With the break statement we can stop the loop before it has looped through all the items:

Example

Exit the loop when x is "banana":

```
fruits = ["apple", "banana", "cherry"]
for x in fruits:
  print(x)
  if x == "banana":
    break
```

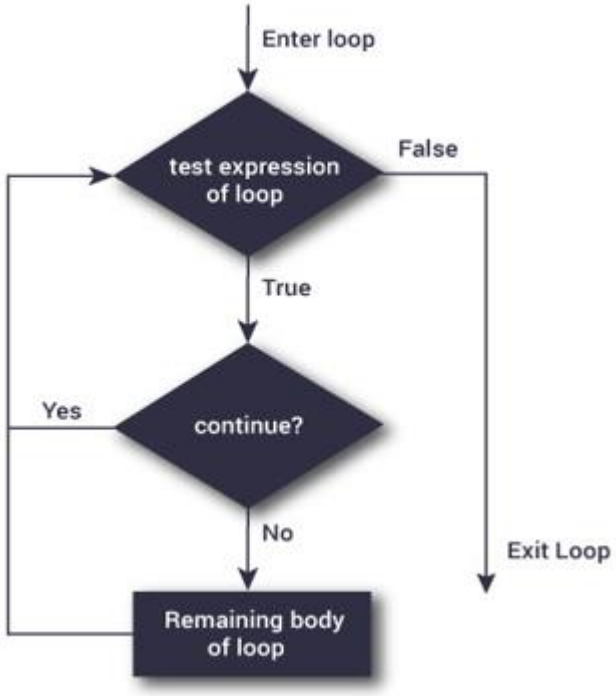
Example

Exit the loop when x is "banana", but this time the break comes before the print:

```
fruits = ["apple", "banana", "cherry"]
for x in fruits:
  if x == "banana":
    break
  print(x)
```

The continue Statement

With the continue statement we can stop the current iteration, and continue with the next:



Example

Continue to the next iteration if i is 3:

```
i = 0
while i < 6:
  i += 1
  if i == 3:
    continue
  print(i)
```

With the continue statement we can stop the current iteration of the loop, and continue with the next:

Example

Do not print banana:

```
fruits = ["apple", "banana", "cherry"]
for x in fruits:
  if x == "banana":
    continue
  print(x)
```

The pass Statement

for loops cannot be empty, but if you for some reason have a for loop with no content, put in the pass statement to avoid getting an error.

Example

```
for x in [0, 1, 2]:
  pass
```

Lecture 10.1

Python Functions

- **Lecture Objective:** Discuss need and use of functions in Python.
- **Lecture Outcome:** Develop the application programs using user defined functions

In Python, a function is a group of related statements that performs a specific task. Functions help break our program into smaller and modular chunks. As our program grows larger and larger, functions make it more organized and manageable. Furthermore, it avoids repetition and makes the code reusable.

Types of Functions

Basically, we can divide functions into the following two types:

1. Built-in functions - Functions that are built into Python.
2. User-defined functions - Functions defined by the users themselves.

Syntax of Function

```
def function_name(parameters):
        """docstring"""
        statement(s)
```

Above shown is a function definition that consists of the following components.

1. Keyword `def` that marks the start of the function header.
2. A function name to uniquely identify the function. Function naming follows the same rules of writing identifiers in Python.
3. Parameters (arguments) through which we pass values to a function. They are optional.
4. A colon (:) to mark the end of the function header.
5. Optional documentation string (docstring) to describe what the function does.
6. One or more valid python statements that make up the function body. Statements must have the same indentation level (usually 4 spaces).
7. An optional `return` statement to return a value from the function.

Example of a function

```
def greet(name):
    """
    This function greets to
    the person passed in as
    a parameter
    """
    print("Hello, " + name + ". Good morning!")
```

How to call a function in python?

Once we have defined a function, we can call it from another function, program or even the Python prompt. To call a function we simply type the function name with appropriate parameters.

```
>>> greet('Paul')
Hello, Paul. Good morning!
```

```
def greet(name):
    """
    This function greets to
```

```
    the person passed in as
    a parameter
    """
    print("Hello, " + name + ". Good morning!")

greet('Paul')
```

Docstrings

The first string after the function header is called the docstring and is short for documentation string. It is briefly used to explain what a function does.

Although optional, documentation is a good programming practice. Unless you can remember what you had for dinner last week, always document your code.

In the above example, we have a docstring immediately below the function header. We generally use triple quotes so that docstring can extend up to multiple lines. This string is available to us as the `__doc__` attribute of the function.

The return statement

The `return` statement is used to exit a function and go back to the place from where it was called.

Syntax of return

```
return [expression_list]
```

This statement can contain an expression that gets evaluated and the value is returned. If there is no expression in the statement or the `return` statement itself is not present inside a function, then the function will return the `None` object.

For example:

```
>>> print(greet("May"))
Hello, May. Good morning!
None
```

Here, `None` is the returned value since `greet()` directly prints the name and no `return` statement is used.

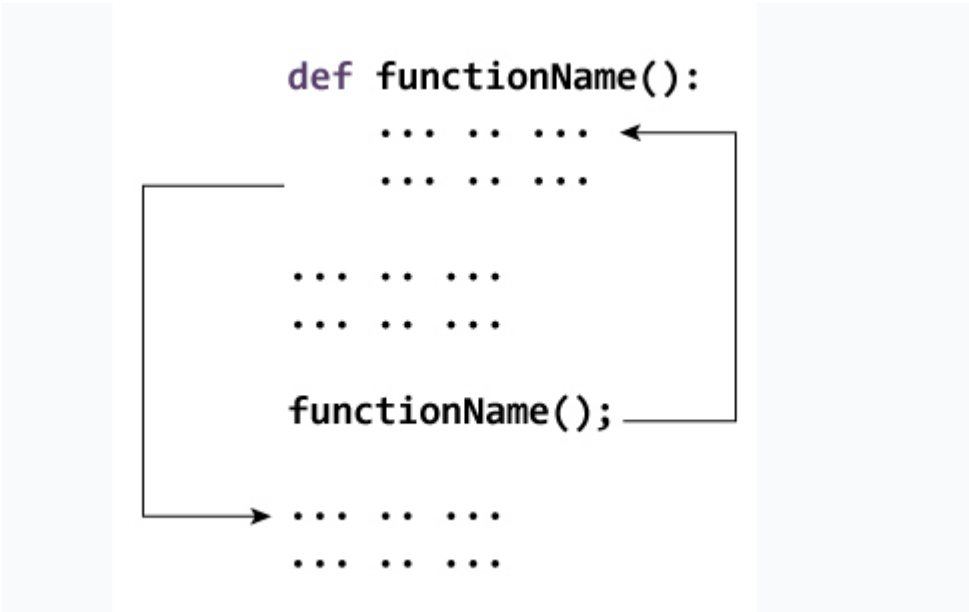
Example of return

```
def absolute_value(num):
    """This function returns the absolute
    value of the entered number"""

    if num >= 0:
        return num
    else:
        return -num


print(absolute_value(2))

print(absolute_value(-4))
```

Output

```
2
4
```

How Function works in Python?



```
def my_func():
        x = 10
        print("Value inside function:",x)
x = 20
my_func()
print("Value outside function:",x)
```

Lecture 10.2

Python Functions

Scope and Lifetime of variables

Scope of a variable is the portion of a program where the variable is recognized. Parameters and variables defined inside a function are not visible from outside the function. Hence, they have a local scope.

The lifetime of a variable is the period throughout which the variable exits in the memory. The lifetime of variables inside a function is as long as the function executes.

They are destroyed once we return from the function. Hence, a function does not remember the value of a variable from its previous calls.

Here is an example to illustrate the scope of a variable inside a function.

```
def my_func():
        x = 10
        print("Value inside function:",x)

x = 20
my_func()
print("Value outside function:",x)
```

Output

```
Value inside function: 10
```

```
Value outside function: 20
```

Here, we can see that the value of `x` is 20 initially. Even though the function `my_func()` changed the value of `x` to 10, it did not affect the value outside the function.

This is because the variable `x` inside the function is different (local to the function) from the one outside. Although they have the same names, they are two different variables with different scopes.

On the other hand, variables outside of the function are visible from inside. They have a global scope.

We can read these values from inside the function but cannot change (write) them. In order to modify the value of variables outside the function, they must be declared as global variables using the keyword `global`.

Python Function:

A function is a block of code which only runs when it is called. You can pass data, known as parameters, into a function. A function can return data as a result.

Creating a Function

In Python a function is defined using the `def` keyword:

Example

```
def my_function():
  print("Hello from a function")
```

Calling a Function

To call a function, use the function name followed by parenthesis:

Example

```
def my_function():
  print("Hello from a function")
```

my_function()

Function Arguments

1. Required Arguments:

Information can be passed into functions as arguments.

Arguments are specified after the function name, inside the parentheses. You can add as many arguments as you want, just separate them with a comma.

The following example has a function with one argument (fname). When the function is called, we pass along a first name, which is used inside the function to print the full name:

Example

```
def my_function(fname):
  print(fname + " Refsnes")

my_function("Emil")
my_function("Tobias")
my_function("Linus")
```

Parameters or Arguments?

The terms *parameter* and *argument* can be used for the same thing: information that are passed into a function.

From a function's perspective:

A parameter is the variable listed inside the parentheses in the function definition.

An argument is the value that is sent to the function when it is called.

Number of Arguments

By default, a function must be called with the correct number of arguments. Meaning that if your function expects 2 arguments, you have to call the function with 2 arguments, not more, and not less.

Example

This function expects 2 arguments, and gets 2 arguments:

```
def my_function(fname, lname):
  print(fname + " " + lname)

my_function("Emil", "Refsnes")
```

If you try to call the function with 1 or 3 arguments, you will get an error:

Example

This function expects 2 arguments, but gets only 1:

```
def my_function(fname, lname):
  print(fname + " " + lname)

my_function("Emil")
```

Arbitrary Arguments, *args

If you do not know how many arguments that will be passed into your function, add a * before the parameter name in the function definition.

This way the function will receive a *tuple* of arguments, and can access the items accordingly:

Example

If the number of arguments is unknown, add a * before the parameter name:

```
def my_function(*kids):
  print("The youngest child is " + kids[2])

my_function("Emil", "Tobias", "Linus")
```

rbitrary Arguments are often shortened to **args* in Python documentations.

---

2. Keyword Arguments:

You can also send arguments with the *key* = *value* syntax.

This way the order of the arguments does not matter.

Example

```
def my_function(child3, child2, child1):
  print("The youngest child is " + child3)
```

```
my_function(child1 = "Emil", child2 = "Tobias", child3 = "Linus")
```

The phrase *Keyword Arguments* are often shortened to *kwargs* in Python documentations.

---

3. Arbitrary Keyword Arguments, **kwargs:

If you do not know how many keyword arguments that will be passed into your function, add two asterisk: ** before the parameter name in the function definition.

This way the function will receive a *dictionary* of arguments, and can access the items accordingly:

Example

If the number of keyword arguments is unknown, add a double ** before the parameter name:

```
def my_function(**kid):
  print("His last name is " + kid["lname"])

my_function(fname = "Tobias", lname = "Refsnes")
```

4. Default Parameter Value:

The following example shows how to use a default parameter value.

If we call the function without argument, it uses the default value:

Example

```
def my_function(country = "Norway"):
  print("I am from " + country)

my_function("Sweden")
my_function("India")
my_function()
my_function("Brazil")
```

Passing a List as an Argument

You can send any data types of argument to a function (string, number, list, dictionary etc.), and it will be treated as the same data type inside the function.

E.g. if you send a List as an argument, it will still be a List when it reaches the function:

Example

```
def my_function(food):
  for x in food:
    print(x)

fruits = ["apple", "banana", "cherry"]

my_function(fruits)
```

Return Values

To let a function return a value, use the `return` statement:

Example

```
def my_function(x):
  return 5 * x

print(my_function(3))
print(my_function(5))
print(my_function(9))
```

Recursion:

Python also accepts function recursion, which means a defined function can call itself.

Recursion is a common mathematical and programming concept. It means that a function calls itself. This has the benefit of meaning that you can loop through data to reach a result.

The developer should be very careful with recursion as it can be quite easy to slip into writing a function which never terminates, or one that uses excess amounts of memory or processor power. However, when written correctly recursion can be a very efficient and mathematically-elegant approach to programming.

In this example, `tri_recursion()` is a function that we have defined to call itself ("recurse"). We use the `k` variable as the data, which decrements (`-1`) every time we recurse. The recursion ends when the condition is not greater than 0 (i.e. when it is 0).

To a new developer it can take some time to work out how exactly this works, best way to find out is by testing and modifying it.

Example

Recursion Example

```
def tri_recursion(k):
  if(k > 0):
    result = k + tri_recursion(k - 1)
    print(result)
  else:
    result = 0
  return result

print("\n\nRecursion Example Results")
tri_recursion(6)
```

Python Lambda

A lambda function is a small anonymous function. A lambda function can take any number of arguments, but can only have one expression.

Syntax

lambda *arguments* : *expression*

The expression is executed and the result is returned:

Example

A lambda function that adds 10 to the number passed in as an argument, and print the result:

```
x = lambda a : a + 10
print(x(5))
```

Lambda functions can take any number of arguments:

Example

A lambda function that multiplies argument a with argument b and print the result:

```
x = lambda a, b : a * b
print(x(5, 6))
```

Example

A lambda function that sums argument a, b, and c and print the result:

```
x = lambda a, b, c : a + b + c
print(x(5, 6, 2))
```

Why Use Lambda Functions?

The power of lambda is better shown when you use them as an anonymous function inside another function.

Say you have a function definition that takes one argument, and that argument will be multiplied with an unknown number:

```
def myfunc(n):
  return lambda a : a * n
```

Use that function definition to make a function that always doubles the number you send in:

Example

```
def myfunc(n):
  return lambda a : a * n

mydoubler = myfunc(2)

print(mydoubler(11))
```

Or, use the same function definition to make a function that always *triples* the number you send in:

Example

```
def myfunc(n):
  return lambda a : a * n

mytripler = myfunc(3)

print(mytripler(11))
```

Or, use the same function definition to make both functions, in the same program:

Example

```
def myfunc(n):
  return lambda a : a * n

mydoubler = myfunc(2)
mytripler = myfunc(3)

print(mydoubler(11))
print(mytripler(11))
```

Use lambda functions when an anonymous function is required for a short period of time.

Lecture 11.1

Python Comprehensions

- **Lecture Objective:** Discuss features that provide us with a short and concise way to construct new sequences using comprehension.
- **Lecture Outcome:** Understand power of Python list, Dictionary and set comprehensions and their features.

Comprehensions in Python provide us with a short and concise way to construct new sequences (such as lists, set, dictionary etc.) using sequences which have been already defined. Python supports the following 4 types of comprehensions:

- List Comprehensions
- Dictionary Comprehensions
- Set Comprehensions
- Generator Comprehensions

1. List Comprehensions:

List Comprehensions provide an elegant way to create new lists. The following is the basic structure of a list comprehension:

output_list = [output_exp for var in input_list if (var satisfies this condition)]

Note that list comprehension may or may not contain an if condition. List comprehensions can contain multiple **for** (nested list comprehensions).
Example #1: Suppose we want to create an output list which contains only the even numbers which are present in the input list. Let's see how to do this using *for loops* and *list comprehension* and decide which method suits better.

```
# Constructing output list WITHOUT
# Using List comprehensions
input_list = [1, 2, 3, 4, 4, 5, 6, 7, 7]

output_list = []

# Using loop for constructing output list

for var in input_list:
   if var % 2 == 0:
      output_list.append(var)

print("Output List using for loop:", output_list)
```

Output:

```
Output List using for loop: [2, 4, 4, 6]
```

```
# Using List comprehensions
# for constructing output list

input_list = [1, 2, 3, 4, 4, 5, 6, 7, 7]


list_using_comp = [var for var in input_list if var % 2 == 0]

print("Output List using list comprehensions:", list_using_comp)
```

Output:

```
Output List using list comprehensions: [2, 4, 4, 6]
```

Example #2: Suppose we want to create an output list which contains squares of all the numbers from 1 to 9. Let's see how to do this using for loops and list comprehension.

```
# Constructing output list using for loop
output_list = []
for var in range(1, 10):
   output_list.append(var ** 2)

print("Output List using for loop:", output_list)
```

Output:

```
Output List using for loop: [1, 4, 9, 16, 25, 36, 49, 64, 81]
```

```
# Constructing output list
# using list comprehension
list_using_comp = [var**2 for var in range(1, 10)]

print("Output List using list comprehension:",  list_using_comp)
```

Output:

```
Output List using list comprehension: [1, 4, 9, 16, 25, 36, 49, 64, 81]
```

2. Dictionary Comprehensions:

Extending the idea of list comprehensions, we can also create a dictionary using dictionary comprehensions. The basic structure of a dictionary comprehension looks like below.

output_dict = {key:value for (key, value) in iterable if (key, value satisfy this condition)}

Example #1: Suppose we want to create an output dictionary which contains only the odd numbers that are present in the input list as keys and their cubes as values. Let's see how to do this using for loops and dictionary comprehension.

```
input_list = [1, 2, 3, 4, 5, 6, 7]

output_dict = {}

# Using loop for constructing output dictionary

for var in input_list:
   if var % 2 != 0:
      output_dict[var] = var**3

print("Output Dictionary using for loop:", output_dict )
```

Output:

```
Output Dictionary using for loop: {1: 1, 3: 27, 5: 125, 7: 343}
```

```
# Using Dictionary comprehensions
# for constructing output dictionary

input_list = [1,2,3,4,5,6,7]

dict_using_comp = {var:var ** 3 for var in input_list if var % 2 != 0}

print("Output Dictionary using dictionary comprehensions:",  dict_using_comp)
```

Output:

```
Output Dictionary using dictionary comprehensions: {1: 1, 3: 27, 5: 125, 7: 343}
```

Example #2: Given two lists containing the names of states and their corresponding capitals, construct a dictionary which maps the states with their respective capitals. Let's see how to do this using for loops and dictionary comprehension.

```
state = ['Gujarat', 'Maharashtra', 'Rajasthan']
capital = ['Gandhinagar', 'Mumbai', 'Jaipur']

output_dict = {}

# Using loop for constructing output dictionary

for (key, value) in zip(state, capital):
   output_dict[key] = value

print("Output Dictionary using for loop:",
                  output_dict)
```

Output:

```
Output Dictionary using for loop: {'Gujarat': 'Gandhinagar',   'Maharashtra': 'Mumbai',
                                   'Rajasthan': 'Jaipur'}
```

```
# Using Dictionary comprehensions
# for constructing output dictionary

state = ['Gujarat', 'Maharashtra', 'Rajasthan']
capital = ['Gandhinagar', 'Mumbai', 'Jaipur']

dict_using_comp = {key:value for (key, value) in zip(state, capital)}

print("Output Dictionary using dictionary comprehensions:", dict_using_comp)
```

Output:

```
Output Dictionary using dictionary comprehensions: {'Rajasthan': 'Jaipur',
                                                    'Maharashtra': 'Mumbai',
                                                    'Gujarat': 'Gandhinagar'}
```

3. Set Comprehensions:

Set comprehensions are pretty similar to list comprehensions. The only difference between them is that set comprehensions use curly brackets { }. Let's look at the following example to understand set comprehensions.

Example #1 : Suppose we want to create an output set which contains only the even numbers that are present in the input list. Note that set will discard all the duplicate values. Let's see how we can do this using for loops and set comprehension.

```
input_list = [1, 2, 3, 4, 4, 5, 6, 6, 6, 7, 7]

output_set = set()

# Using loop for constructing output set
for var in input_list:
   if var % 2 == 0:
      output_set.add(var)

print("Output Set using for loop:", output_set)
```

Output:

```
Output Set using for loop: {2, 4, 6}
```

```
# Using Set comprehensions
# for constructing output set
```

```
input_list = [1, 2, 3, 4, 4, 5, 6, 6, 6, 7, 7]

set_using_comp = {var for var in input_list if var % 2 == 0}

print("Output Set using set comprehensions:",
                    set_using_comp)
```

Output:

```
Output Set using set comprehensions: {2, 4, 6}
```

Lecture 11.2

Python Exception

Python provides two very important features to handle any unexpected error in your Python programs and to add debugging capabilities in them –

- **Exception Handling** –
- **Assertions** –

- **List of Standard Exceptions –**

Sr.No.	Exception Name & Description
1	**Exception** Base class for all exceptions
2	**StopIteration** Raised when the next() method of an iterator does not point to any object.
3	**SystemExit** Raised by the sys.exit() function.
4	**StandardError** Base class for all built-in exceptions except StopIteration and SystemExit.
5	**ArithmeticError** Base class for all errors that occur for numeric calculation.

6	**OverflowError** Raised when a calculation exceeds maximum limit for a numeric type.
7	**FloatingPointError** Raised when a floating point calculation fails.
8	**ZeroDivisionError** Raised when division or modulo by zero takes place for all numeric types.
9	**AssertionError** Raised in case of failure of the Assert statement.
10	**AttributeError** Raised in case of failure of attribute reference or assignment.
11	**EOFError** Raised when there is no input from either the raw_input() or input() function and the end of file is reached.
12	**ImportError** Raised when an import statement fails.
13	**KeyboardInterrupt** Raised when the user interrupts program execution, usually by pressing Ctrl+c.
14	**LookupError** Base class for all lookup errors.
15	**IndexError** Raised when an index is not found in a sequence.
16	**KeyError** Raised when the specified key is not found in the dictionary.

17	**NameError** Raised when an identifier is not found in the local or global namespace.
18	**UnboundLocalError** Raised when trying to access a local variable in a function or method but no value has been assigned to it.
19	**EnvironmentError** Base class for all exceptions that occur outside the Python environment.
20	**IOError** Raised when an input/ output operation fails, such as the print statement or the open() function when trying to open a file that does not exist.
21	**IOError** Raised for operating system-related errors.
22	**SyntaxError** Raised when there is an error in Python syntax.
23	**IndentationError** Raised when indentation is not specified properly.
24	**SystemError** Raised when the interpreter finds an internal problem, but when this error is encountered the Python interpreter does not exit.
25	**SystemExit** Raised when Python interpreter is quit by using the sys.exit() function. If not handled in the code, causes the interpreter to exit.
26	**TypeError** Raised when an operation or function is attempted that is invalid for the specified data type.

27	**ValueError** Raised when the built-in function for a data type has the valid type of arguments, but the arguments have invalid values specified.
28	**RuntimeError** Raised when a generated error does not fall into any category.
29	**NotImplementedError** Raised when an abstract method that needs to be implemented in an inherited class is not actually implemented.

Assertions in Python

An assertion is a sanity-check that you can turn on or turn off when you are done with your testing of the program.

The easiest way to think of an assertion is to liken it to a **raise-if** statement (or to be more accurate, a raise-if-not statement). An expression is tested, and if the result comes up false, an exception is raised.

Assertions are carried out by the assert statement, the newest keyword to Python, introduced in version 1.5.

Programmers often place assertions at the start of a function to check for valid input, and after a function call to check for valid output.

The *assert* Statement

When it encounters an assert statement, Python evaluates the accompanying expression, which is hopefully true. If the expression is false, Python raises an *AssertionError* exception.

The **syntax** for assert is −

assert Expression[, Arguments]

If the assertion fails, Python uses ArgumentExpression as the argument for the AssertionError. AssertionError exceptions can be caught and handled like any other exception using the try-except statement, but if not handled, they will terminate the program and produce a traceback.

What is Exception?

An exception is an event, which occurs during the execution of a program that disrupts the normal flow of the program's instructions. In general, when a Python script

encounters a situation that it cannot cope with, it raises an exception. An exception is a Python object that represents an error.

When a Python script raises an exception, it must either handle the exception immediately otherwise it terminates and quits.

Handling an exception

If you have some *suspicious* code that may raise an exception, you can defend your program by placing the suspicious code in a **try:** block. After the try: block, include an **except:** statement, followed by a block of code which handles the problem as elegantly as possible.

Syntax

Here is simple syntax of *try....except...else* blocks −

```
try:
   You do your operations here;
   ......................
except ExceptionI:
   If there is ExceptionI, then execute this block.
except ExceptionII:
   If there is ExceptionII, then execute this block.
   ......................
else:
   If there is no exception then execute this block.
```

Here are few important points about the above-mentioned syntax −

- A single try statement can have multiple except statements. This is useful when the try block contains statements that may throw different types of exceptions.
- You can also provide a generic except clause, which handles any exception.
- After the except clause(s), you can include an else-clause. The code in the else-block executes if the code in the try: block does not raise an exception.
- The else-block is a good place for code that does not need the try: block's protection.

Example

This example opens a file, writes content in the, file and comes out gracefully because there is no problem at all −

```
#!/usr/bin/python

try:
   fh = open("testfile", "w")
   fh.write("This is my test file for exception handling!!")
except IOError:
```

```
   print "Error: can\'t find file or read data"
else:
   print "Written content in the file successfully"
   fh.close()
```

This produces the following result –

Written content in the file successfully

Example

This example tries to open a file where you do not have write permission, so it raises an exception –

```
#!/usr/bin/python
```

```
try:
   fh = open("testfile", "r")
   fh.write("This is my test file for exception handling!!")
except IOError:
   print "Error: can\'t find file or read data"
else:
   print "Written content in the file successfully"
```

This produces the following result –

Error: can't find file or read data

The *except* Clause with No Exceptions

You can also use the except statement with no exceptions defined as follows –

```
try:
   You do your operations here;
   ......................
except:
   If there is any exception, then execute this block.
   ......................
else:
   If there is no exception then execute this block.
```

This kind of a **try-except** statement catches all the exceptions that occur. Using this kind of try-except statement is not considered a good programming practice though, because it catches all exceptions but does not make the programmer identify the root cause of the problem that may occur.

The *except* Clause with Multiple Exceptions

You can also use the same *except* statement to handle multiple exceptions as follows –

```
try:
   You do your operations here;
   ......................
except(Exception1[, Exception2[,...ExceptionN]]]):
   If there is any exception from the given exception list,
   then execute this block.
   ......................
else:
   If there is no exception then execute this block.
```

The try-finally Clause

You can use a **finally:** block along with a **try:** block. The finally block is a place to put any code that must execute, whether the try-block raised an exception or not. The syntax of the try-finally statement is this –

```
try:
   You do your operations here;
   ......................
   Due to any exception, this may be skipped.
finally:
   This would always be executed.
   ......................
```

You cannot use *else* clause as well along with a finally clause.

Example

```
#!/usr/bin/python

try:
   fh = open("testfile", "w")
   fh.write("This is my test file for exception handling!!")
finally:
   print "Error: can\'t find file or read data"
```

If you do not have permission to open the file in writing mode, then this will produce the following result –

```
Error: can't find file or read data
```

Same example can be written more cleanly as follows –

```
#!/usr/bin/python

try:
   fh = open("testfile", "w")
   try:
      fh.write("This is my test file for exception handling!!")
   finally:
      print "Going to close the file"
      fh.close()
```

```
except IOError:
   print "Error: can\'t find file or read data"
```

When an exception is thrown in the *try* block, the execution immediately passes to the *finally* block. After all the statements in the *finally* block are executed, the exception is raised again and is handled in the *except* statements if present in the next higher layer of the *try-except* statement.

Argument of an Exception

An exception can have an *argument*, which is a value that gives additional information about the problem. The contents of the argument vary by exception. You capture an exception's argument by supplying a variable in the except clause as follows –

```
try:
   You do your operations here;
   ......................
except ExceptionType, Argument:
   You can print value of Argument here...
```

If you write the code to handle a single exception, you can have a variable follow the name of the exception in the except statement. If you are trapping multiple exceptions, you can have a variable follow the tuple of the exception.

This variable receives the value of the exception mostly containing the cause of the exception. The variable can receive a single value or multiple values in the form of a tuple. This tuple usually contains the error string, the error number, and an error location.

Example

Following is an example for a single exception –

```
#!/usr/bin/python

# Define a function here.
def temp_convert(var):
   try:
      return int(var)
   except ValueError, Argument:
      print "The argument does not contain numbers\n", Argument

# Call above function here.
temp_convert("xyz");
```

This produces the following result –

```
The argument does not contain numbers
invalid literal for int() with base 10: 'xyz'
```

Raising an Exceptions

You can raise exceptions in several ways by using the raise statement. The general syntax for the **raise** statement is as follows.

Syntax

raise [Exception [, args [, traceback]]]

Here, *Exception* is the type of exception (for example, NameError) and *argument* is a value for the exception argument. The argument is optional; if not supplied, the exception argument is None.

The final argument, traceback, is also optional (and rarely used in practice), and if present, is the traceback object used for the exception.

Example

An exception can be a string, a class or an object. Most of the exceptions that the Python core raises are classes, with an argument that is an instance of the class. Defining new exceptions is quite easy and can be done as follows –

```
def functionName( level ):
  if level < 1:
    raise "Invalid level!", level
    # The code below to this would not be executed
    # if we raise the exception
```

Note: In order to catch an exception, an "except" clause must refer to the same exception thrown either class object or simple string. For example, to capture above exception, we must write the except clause as follows –

```
try:
  Business Logic here...
except "Invalid level!":
  Exception handling here...
else:
  Rest of the code here...
```

User-Defined Exceptions

Python also allows you to create your own exceptions by deriving classes from the standard built-in exceptions.

Here is an example related to *RuntimeError*. Here, a class is created that is subclassed from *RuntimeError*. This is useful when you need to display more specific information when an exception is caught.

In the try block, the user-defined exception is raised and caught in the except block. The variable e is used to create an instance of the class *Networkerror*.

```
class Networkerror(RuntimeError):
  def __init__(self, arg):
    self.args = arg
```

So once you defined above class, you can raise the exception as follows −

```
try:
  raise Networkerror("Bad hostname")
except Networkerror,e:
  print e.args
```