Exception And Assertions

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

- **Exception Handling** − This would be covered in this tutorial. Here is a list standard Exceptions available in Python: Standard Exceptions.
- **Assertions** − This would be covered in Assertions in Python tutorial.

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.

Example

Here is a function that converts a temperature from degrees Kelvin to degrees Fahrenheit. Since zero degrees Kelvin is as cold as it gets, the function bails out if it sees a negative temperature −

```
#!/usr/bin/python

def KelvinToFahrenheit(Temperature):

   assert (Temperature >= 0),"Colder than absolute zero!"

   return ((Temperature-273)*1.8)+32

print KelvinToFahrenheit(273)

print int(KelvinToFahrenheit(505.78))
```

```
print KelvinToFahrenheit(-5)
```

When the above code is executed, it produces the following result −

```
32.0
451
Traceback (most recent call last):
File "test.py", line 9, in <module>
print KelvinToFahrenheit(-5)
File "test.py", line 4, in KelvinToFahrenheit
assert (Temperature >= 0),"Colder than absolute zero!"
AssertionError: Colder than absolute zero!
```

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
```

File handling

What is a file?

File is a named location on disk to store related information. It is used to permanently store data in a non-volatile memory (e.g. hard disk).

Since, random access memory (RAM) is volatile which loses its data when computer is turned off, we use files for future use of the data.

When we want to read from or write to a file we need to open it first. When we are done, it needs to be closed, so that resources that are tied with the file are freed.

Hence, in Python, a file operation takes place in the following order.

1. Open a file
2. Read or write (perform operation)
3. Close the file

How to open a file?

Python has a built-in function `open()` to open a file. This function returns a file object, also called a handle, as it is used to read or modify the file accordingly.

```
>>> f = open("test.txt")    # open file in current directory
>>> f = open("C:/Python33/README.txt")  # specifying full path
```

We can specify the mode while opening a file. In mode, we specify whether we want to read `'r'`, write `'w'` or append `'a'` to the file. We also specify if we want to open the file in text mode or binary mode.

The default is reading in text mode. In this mode, we get strings when reading from the file.

On the other hand, binary mode returns bytes and this is the mode to be used when dealing with non-text files like image or exe files.

Python File Modes

Mode	Description

'r'	Open a file for reading. (default)
'w'	Open a file for writing. Creates a new file if it does not exist or truncates the file if it exists.
'x'	Open a file for exclusive creation. If the file already exists, the operation fails.
'a'	Open for appending at the end of the file without truncating it. Creates a new file if it does not exist.
't'	Open in text mode. (default)
'b'	Open in binary mode.
'+'	Open a file for updating (reading and writing)

```
f = open("test.txt")      # equivalent to 'r' or 'rt'
f = open("test.txt",'w')  # write in text mode
f = open("img.bmp",'r+b') # read and write in binary mode
```

Unlike other languages, the character `'a'` does not imply the number 97 until it is encoded using `ASCII` (or other equivalent encodings).

Moreover, the default encoding is platform dependent. In windows, it is `'cp1252'` but `'utf-8'` in Linux.

So, we must not also rely on the default encoding or else our code will behave differently in different platforms.

Hence, when working with files in text mode, it is highly recommended to specify the encoding type.

```
f = open("test.txt",mode = 'r',encoding = 'utf-8')
```

How to close a file Using Python?

When we are done with operations to the file, we need to properly close the file.

Closing a file will free up the resources that were tied with the file and is done using Python `close()` method.

Python has a garbage collector to clean up unreferenced objects but, we must not rely on it to close the file.

```
f = open("test.txt",encoding = 'utf-8')
# perform file operations
```

```
f.close()
```

This method is not entirely safe. If an exception occurs when we are performing some operation with the file, the code exits without closing the file.

A safer way is to use a try...finally block.

```
try:
   f = open("test.txt",encoding = 'utf-8')
   # perform file operations
finally:
   f.close()
```

This way, we are guaranteed that the file is properly closed even if an exception is raised, causing program flow to stop.

The best way to do this is using the `with` statement. This ensures that the file is closed when the block inside `with` is exited.

We don't need to explicitly call the `close()` method. It is done internally.

```
with open("test.txt",encoding = 'utf-8') as f:
   # perform file operations
```

How to write to File Using Python?

In order to write into a file in Python, we need to open it in write `'w'`, append `'a'` or exclusive creation `'x'` mode.

We need to be careful with the `'w'` mode as it will overwrite into the file if it already exists. All previous data are erased.

Writing a string or sequence of bytes (for binary files) is done using `write()` method. This method returns the number of characters written to the file.

```
with open("test.txt",'w',encoding = 'utf-8') as f:
   f.write("my first file\n")
   f.write("This file\n\n")
   f.write("contains three lines\n")
```

This program will create a new file named `'test.txt'` if it does not exist. If it does exist, it is overwritten.

We must include the newline characters ourselves to distinguish different lines.

How to read files in Python?

To read a file in Python, we must open the file in reading mode.

There are various methods available for this purpose. We can use the `read(size)` method to read in `size` number of data. If `size` parameter is not specified, it reads and returns up to the end of the file.

```
>>> f = open("test.txt",'r',encoding = 'utf-8')
>>> f.read(4)    # read the first 4 data
'This'

>>> f.read(4)    # read the next 4 data
' is '

>>> f.read()     # read in the rest till end of file
'my first file\nThis file\ncontains three lines\n'

>>> f.read()  # further reading returns empty sting
''
```

We can see that, the `read()` method returns newline as `'\n'`. Once the end of file is reached, we get empty string on further reading.

We can change our current file cursor (position) using the `seek()` method. Similarly, the `tell()` method returns our current position (in number of bytes).

```
>>> f.tell()    # get the current file position
56

>>> f.seek(0)   # bring file cursor to initial position
0

>>> print(f.read())  # read the entire file
```

```
This is my first file
This file
contains three lines
```

We can read a file line-by-line using a for loop. This is both efficient and fast.

```
>>> for line in f:
...     print(line, end = '')
...
This is my first file
This file
contains three lines
```

The lines in file itself has a newline character `'\n'`.

Moreover, the `print()` end parameter to avoid two newlines when printing.

Alternately, we can use `readline()` method to read individual lines of a file. This method reads a file till the newline, including the newline character.

```
>>> f.readline()
'This is my first file\n'

>>> f.readline()
'This file\n'

>>> f.readline()
'contains three lines\n'

>>> f.readline()
''
```

Lastly, the `readlines()` method returns a list of remaining lines of the entire file. All these reading method return empty values when end of file (EOF) is reached.

```
>>> f.readlines()
['This is my first file\n', 'This file\n', 'contains three lines\n']
```

Python File Methods

There are various methods available with the file object. Some of them have been used in above examples.

Here is the complete list of methods in text mode with a brief description.

Python File Methods	
Method	Description
close()	Close an open file. It has no effect if the file is already closed.
detach()	Separate the underlying binary buffer from the `TextIOBase`and return it.
fileno()	Return an integer number (file descriptor) of the file.
flush()	Flush the write buffer of the file stream.
isatty()	Return `True` if the file stream is interactive.
read(`n`)	Read atmost `n` characters form the file. Reads till end of file if it is negative or `None`.
readable()	Returns `True` if the file stream can be read from.
readline(`n`=-1)	Read and return one line from the file. Reads in at most `n`bytes if specified.
readlines(`n`=-1)	Read and return a list of lines from the file. Reads in at most `n` bytes/characters if specified.
seek(`offset`,`from`=`SEEK_SET`)	Change the file position to `offset` bytes, in reference to `from` (start, current, end).
seekable()	Returns `True` if the file stream supports random access.
tell()	Returns the current file location.
truncate(`size`=`None`)	Resize the file stream to `size` bytes. If `size` is not specified, resize to current location.
writable()	Returns `True` if the file stream can be written to.
write(`s`)	Write string `s` to the file and return the number of characters written.

writelines(`lines`)	Write a list of `lines` to the file.

CSV file

Spreadsheets often export CSV (comma separated values) files, because they are easy to read and write. A csv file is simply consists of values, commas and newlines. While the file is called 'comma separate value' file, you can use another separator such as the pipe character.

Create a spreadsheet file (CSV) in Python

Let us create a file in CSV format with Python. We will use the comma character as seperator or delimter.

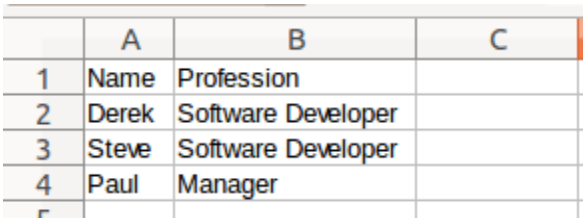
```
import csv

with open('persons.csv', 'wb') as csvfile:
    filewriter = csv.writer(csvfile, delimiter=',',
                            quotechar='|', quoting=csv.QUOTE_MINIMAL)
    filewriter.writerow(['Name', 'Profession'])
    filewriter.writerow(['Derek', 'Software Developer'])
    filewriter.writerow(['Steve', 'Software Developer'])
    filewriter.writerow(['Paul', 'Manager'])
```

Running this code will give us this fil persons.csv with this content:

```
Name,Profession
Derek,Software Developer
Steve,Software Developer
Paul,Manager
```

You can import the persons.csv file in your favorite office program.



	A	B	C
1	Name	Profession	
2	Derek	Software Developer	
3	Steve	Software Developer	
4	Paul	Manager	

Read a spreadsheet file (csv)

If you created a csv file, we can read files row by row with the code below:

```
import csv

# open file
with open('persons.csv', 'rb') as f:
    reader = csv.reader(f)

    # read file row by row
    for row in reader:
        print row
```

This will simply show every row as a list:

```
['Name', 'Profession']
['Derek', 'Software Developer']
['Steve', 'Software Developer']
['Paul', 'Manager']
```

Perhaps you want to store that into Python lists. We get the data from the csv file and then store it into Python lists. We skip the header with an if statement because it does not belong in the lists. Full code:

```
import csv

# create list holders for our data.
names = []
jobs = []

# open file
with open('persons.csv', 'rb') as f:
    reader = csv.reader(f)

    # read file row by row
    rowNr = 0
    for row in reader:
        # Skip the header row.
        if rowNr >= 1:
            names.append(row[0])
            jobs.append(row[1])

        # Increase the row number
```

```
        rowNr = rowNr + 1

# Print data
print names
print jobs
```

Result:

```
['Derek', 'Steve', 'Paul']
['Software Developer', 'Software Developer', 'Manager']
```