Python Part 1 - Overview, Data, Operations, and Sequence Control

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| **Overview**   * Python is an **interpreted** language. * Python interactive window evaluates statements you type. * **Comments** use **#.** Note that **//** is a numeric operator. * Python source files should use a **.py** file extension. * Python is one of the fastest accepted languages * Python uses **colons** to indicate the end of control statements (e.g., def, if, else, elif, for, while, try, except). For programmers who started with other languages, Python has caused remarks such as it being a "pain in the colon". * **There are many useful libraries**   **Data**   * **No** explicit **declaration** of variables. Variables receive their data type, structure, size, and value from assignment. * **Numeric** values have **unlimited range** * Strings are immutable * Associative arrays are called **dictionaries** * **Slices** of arrays are provided   **Bindings**   * Excluding language definition and implementation, bindings are at runtime.   **Storage Mgt**   * A stack is used for managing   + Return location   + Dictionary of local variables (or a C array in some implementations) * Globals are kept in a dictionary * Values are maintained in dynamic memory * Virtual machine is responsible for managing memory including reference counting and garbage collection   **Scope**   * Uses **static scoping** * Functions can be **nested** inside other functions * By default, **assignments** make variables **local** * Nonlocal references are to either nonlocal variables in surrounding functions or to global variables * **Global** statement allows assignment to a global variable in a function * **Nonlocal** statement allows assignment to a nonlocal variable in a function   **Parameter Passing**   * Uses **by value object reference;** it copies a reference to the object   **Operations**   * Functions can **return multiple values** * **Assignments** support **chaining**, **multi-target**, copying an **array reference**, and **array slices**   **Sequence Control**   * Compound statements are indicated by **indentation** instead of {} as in C or DO END as in PL/I. * Python(as of Python 3) doe **not** provide a case statement. | Browser-based interpreter:  <https://repl.it/languages/python3>   * In the left window, you can paste code. If you press the **run>** button, it will execute it in the right window. * Alternatively, in the right window, you can press **CTRL-V** to paste code into it.   Linux **fox** machines:  python3 *filename*.py   * Do **not** use the **python** command since it invokes an old version of python. * Note that your programs will be graded based on **python3** on a fox machine.   VDI:  You can launch it from the Start button.  PyCharm: a reasonable IDE  **Installing PyCharm on Windows**  <https://www.jetbrains.com/pycharm/download/#section=windows>  > Select the free **community** download  **Example #1: function to count As in a list**  >>> # function numAs counts the number of grades >= 90  def numAs (list):  count = 0  for num in list:  if num >= 90:  count+=1  return count  >>> grades = [85, 90, 65, 99] # list of grades  >>> numAs(grades)  2 |
| **Primitives**  Primitives(integer, float, boolean) in Python are actually objects. Numeric values have unlimited range.  Note that Python doesn't support negative numeric constants. A value, -5, is considered a unary negation operator followed by the numeric constant 5.  Why are numerics represented as objects?  ??  Numeric operators:  + addition  - subtraction (or negation if only one operand)  \* multiplication  / division which doesn't truncate  // division which truncates the result  \*\* exponentiation  % modulo operator yields the remainder  ~ bitwise not  << bitwise left shift  << bitwise right shift  & bitwise and  | bitwise or  ^ bitwise XOR  < less than  > greater than  == equal to  >= greater than or equal to  <= less than or equal to  != not equal to  Boolean operators:  or logical or (short circuits)  and logical and (short circuits)  not logical not | |  |  |  | | --- | --- | --- | | **Data Type** | **Example Constants** | **Comments** | | bool | True, False | Constants True and False have values 1 and 0 respectively, but print as **True** and **False**. | | integer | 5, 10, 2,  0x23A (hex constant) | There is an unlimited range of values in Python. | | float | 3.14, 5., 0.005,  1.5e20 |  | | complex | 5j, 1.5e20j | Imaginary numbers |   **Example #2: Division and Remainder**  >>> 3 / 2  1.5  >>> 3 // 2  1  >>> 5 % 3  2  >>> 3.0 // 2.0  1.0  **Example #3: Conditional Expressions**  >>> x = 20  >>> x > 0 and x < 50 # True if x > 0 and x < 50.  True  >>> 0 < x < 50 # More natural comparison of x being between 0 and 50  True |
| Precedence (lowest to highest):  or  and  not  in, not in, is , is not, <, >, <=, >=, ==, !=  |  ^  &  <<, >>  +, -  \*, /, //, %  ~, unary -, unary +  \*\*  When precedences are the same, it evaluates from left-to-right except for exponentiation.  General rules for the data type of a result of numeric operations:  1. If either value is complex, the result is complex.  2. If either value is float, the result is float. If the other is integer, automatically convert it to float.  3. Both values are integer, so no conversion except the result of a / is a float. | **Example #4: Precedence**  >>> 2 + 5 \* 4 - 1 / 2 # First does the multiplication (5 \* 4)  21.5 # yielding 20,  # then the division yielding 0.5,  # then the addition of 2 + 20 yielding 22,  # then the subtraction 22 - 0.5  # giving the result 21.5  >>> 2 \*\* 2 \*\* 3 # First does 2 \*\* 3 yielding 8,  256 # then it does 2 \*\* 8 yielding 256  >>> 5 % 2 \* 9 // 4 # 1 \* 9 // 4  2 # 9 // 4  # 2 |
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| **Character Strings**   * literals can be surrounded in " or '; can use \ as an escape * strings are immutable * characters within a string can be referenced by subscripts which begin with 0 and are referenced via [] * negatives subscripts start at -1 for the last item in the list, -2 refers to the next to last item * supports slices * len() function is used for length * strings can be concatenated (producing new strings) * integers and floats can be converted to strings using the **str(*value*)** function * strings can be compared using >, <, <=, >=, !=, == * to convert from a string to an int, use the **int(*strValue*)** function | **Example #5: Accessing String Elements and Slices**  >>> print('I heard Clark say, "Python\'s easy to learn."')  I heard Clark say, "Python's easy to learn."  >>> name = "Bob Wire"  >>> name[0]  'B'  >>> name[7]  'e'  >>> name[-1] # last character  'e'  >>> name[-2] # next to last character  'r'  >>> name[0:3]  'Bob'  >>> name[4:]  'Wire'  >>> name[:3]  ‘Bob’  >>> len(name)  8  >>> name[-10]  IndexError: string index out of range  >>> # Comparison  one = "apple a day"  two = "applet"  >>> one > two  False |
| **Character String Operators**  **in** checks to see if a string is in another string  **not in** checks whether a string is not in another string  **+** concatenation  **\*** replication  **%** string formatting  We will discuss pattern matching in part 3. | **Example #6: String Operators (in, +, \*, %)**  >>> # in operator  one = "apple a day"  two = "apple"  >>> two in one  True  >>> "APPLE" in one  False  >>> # concatenation uses + to concatenate two strings  bob2 = name[:3] + " L Head"  print (bob2)  Bob L Head  >>> # convert a number to a string  iq = 40  iqStr = bob2 + " has an IQ of " + str(iq)  >>> iqStr  Bob L Head has an IQ of 40  >>> "." \* 3  '...'  >>> name = "Bob"  >>> name\*3  'BobBobBob'  >>> name = "Bob"  wage = 10.5  yearHire = 2016  >>> "Name is %s, hourly wage is %.1f, year hired is %i" % (name, wage, yearHire)  'Name is Bob, hourly wage is 10.5, year hired is 2016' |
| **Character String Methods**  **isalpha()** True if string only contains alphas  **isdecimal()** True if string only contains numbers  **upper()** Returns uppercase values for the string  **lower()** Returns lowercase values for the string  **strip()** Returns a string with all leading and trailing white space (blanks, tab, newline) removed | **Example #7: String Methods**  >>> phone = "hello"  >>> phone.isalpha()  True  >>> phone.isdecimal()  False  >>> phone = "2102223333"  >>> phone.isalpha()  False  >>> phone.isdecimal()  True  >>> phone = "210.2223333"  >>> phone.isdecimal()  False  >>> name = "Harry Fingers"  >>> name.upper()  'HARRY FINGERS'  >>> name.lower()  'harry fingers'  >>> name = " Harry Fingers\n"  >>> name.strip() gets rid of line feeds  'Harry Fingers' |
| **Character String Methods - split()**  **split()** Creates a list of the tokens from the string using one or more delimiters  split(delim,n) Creates a list of n tokens with the remaining text placed in the last element of the list. The resulting list usually has n+1 entries unless there isn't any remaining text.  the regex module provides a more powerful split:  **re.split(***regExpr, string***)**  *regExpr* is a regular expression (see Python Part 3). *string* is the string to be split. | **Example #8: split method**  >>> # By default, split uses white space characters (blank, tab, \n)) as its delimiters.  text1 = "My phone number is 210-555-4444."  tokenM = text1.split()  >>> tokenM  ['My', 'phone', 'number', 'is', '210-555-4444.']  >>> # Using a slash as a delimiter  text2 = "/home/clark/cs3723"  folderM = text2.split('/')  >>> folderM  **['', 'home', 'clark', 'cs3723']**  >>> # use split() to get the area code and place the rest in the second element  text3 = "210-555-444"  tokenM = text3.**split**('-', 1)  >>> tokenM  **['210', '555-444']**  **Example #9: re.split (you must import re)**  >>> # use re.split(regex, string) from the re module  # Split on semicolon, comma, period or space. Also ignore 0 to many  # spaces after the delimiter.  import re  text4 = "He loved playing basketball; however, he hated watching it on TV."  wordM = re.split("[;,\s\.]\s\*", text4)  >>> wordM  ['He', 'loved', 'playing', 'basketball', 'however', 'he', 'hated', 'watching', 'it', 'on', 'TV', ''] |
| **Character String Methods - centering and justifying**  **rjust(***size, padChar***)**  right justifies the string to *size* bytes. padChar is an optional padding character.  **ljust(***size, padChar***)**  left justifies the string to *size* bytes. padChar is an optional padding character.  **center(***size, padChar***)**  centers the string to *size* bytes. padChar is an optional padding character. | **Example #10: justification methods**  # Right justify to 20 characters using the default space as the padding character  >>> name = 'May King'  >>> name.rjust(20)  ' May King'  # Right justify to 20 characters using the a period as the padding character  >>> name.rjust(20, '.')  '............May King'  # left justify to 20 characters using the a '\*' as the padding character  >>> name.ljust(20,'\*')  'May King\*\*\*\*\*\*\*\*\*\*\*\*'  # center within 20 characters using the a '\*' as the padding character  >>> name.center(20,'\*')  '\*\*\*\*\*\*May King\*\*\*\*\*\*' |
| **Data Structures - lists**   * heterogeneous arrays * unbounded; grows * creation surrounded by []; separate entries with commas * subscripts begin with 0 and are referenced via [] * negative subscripts start at -1 for the last item in the list, -2 refers to the next to last item * supports slices * len() function is used for length * existing entries can be modified by assigning to an individual element * new entries can be added by either constructing a new list via **concatenation** or using the **append** function * prints the entire contents when referenced without subscripts * provides **for in** to iterate over contents * operators: in, not in | **Example #11: accessing list elements and slices**  >>> # create a list of grades  >>> grades = [100, 90, 95, 75]  >>> grades[1]  90  >>> grades[3]  75  >>> grades[-1]  75  >>> grades[-2]  95  >>> grades[0:2] # is a slice which begins at [0] and goes up to (but not including) [2]  [100, 90]  >>> grades[1:] # a slice beginning at [1] to the last element  [90, 95, 75]  >>> grades[:2] # a slice [0:2]  [100, 90]  >>> len(grades)  4  >>> # **replace** the 95 with a 100  grades[2] = 100  **Example #12: adding elements to lists using concatenation or append**  # add another grade onto the list using + to  # **concatenate** two lists creating a **new list**  grades = grades + [90] # grades is now [100, 90, 100, 75, 90]  print(grades)  [100, 90, 100, 75, 90]  >>> # **append** another grade using the append method  >>> grades.append(55)  >>> grades  [100, 90, 100, 75, 90, 55]  **Example #13: iterate over the contents**  >>> # individually print each value  for grade in grades:  print (grade)  100  90  100  75  90  55  >>> 100 in grades  True  >>> 99 in grades  False |
| **Sorting a List**  Lists support a **sort()** method. By default, **sort()** sorts in ascending order.  To sort in descending order, use *list.*sort(reverse=True)  To ignore case, use *list.*sort(key=str.lower) | **Example #14: sorting**  >>> # create a list and sort it in ascending order  fruit = ["banana", "apple", "orange", "Clark", "Slavin", "Maynard"]  fruit.sort()  print(fruit)  **['Clark', 'Maynard', 'Slavin', 'apple', 'banana', 'orange']**  >>> # descending order  fruit.sort(reverse=True)  print(fruit)  >>> # ascending order, ignoring case  fruit.sort(key=str.lower)  print(fruit)  **['apple', 'banana', 'Clark', 'Maynard', 'orange', 'Slavin']**  >>> # descending order, ignoring case  fruit.sort(key=str.lower, reverse=True)  print(fruit)  **['Slavin', 'orange', 'Maynard', 'Clark', 'banana', 'apple']** |
| **Data structures - tuples**   * similar to lists except immutable * creation surrounded by () | **Example #15: tuples are immutable**  >>> # create a tuple that cannot be changed  >>> student = ("Anita Break", 0.01, "CS")  # if we try to change the gpa to 0.02, we would get an assignment error  student[1] = 0.02  TypeError: 'tuple' object does not support item assignment  >>> # we can recreate student using concatenation. Notice that we are concatenating tuples  # instead of changing an element of student.  student = student[0:1] + (0.02,) + student[2:3]  print (student)  ('Anita Break', 0.02, 'CS') |
| **Data structures - dictionary**   * associative array * surround the dictionary in {}; separate key from value using a colon; separate different dictionary entries using commas * use [] when referencing elements * provides **for in** to iterate over contents referenced with **items()**, **keys()** or **values()** methods * **get(*key*,*notExistsValue*)** method is provided to access an entry which might not exist * len(*dictionary*) provides the number of elements * operators: in, not in keys(), values() * entries can be **added** by simply assigning to the dictionary:   dictionary[*keyValue*] = value   * the **sorted**(*dictionary*) function can be used to sort the keys of a dictionary in ascending order. | **Example #16: dictionary**  >>> # Create a contact dictionary  contactD = {"Board, Bill": "830-222-2222"  , "Board, Peg": "830-222-3333"  , "Barr, Ted E": "210-555-1111"}  contactD["Board, Emory"] = contactD["Board, Peg"]; #copy Peg's phone to Emory  # access the key and value, calling them name and phone  for name, phone in contactD.items():  print (name, phone)  Output:  Board, Emory 830-222-3333  Board, Bill 830-222-2222  Barr, Ted E 210-555-1111  Board, Peg 830-222-3333  >>> # try getting some entries  >>> contactD["Board, Bill"]  830-222-2222  >>> contactD["Barr, Candy"]  KeyError: 'Barr, Candy'  >>> # try getting some entries  >>> contactD.get("Board, Peg", "NF")  '830-222-3333'    >>> contactD.get("Barr, Candy", "NF")  'NF'  **Example #17: pprint**  >>> # convenient function to pretty print dictionary entries (sorted by key)  import pprint  pprint.pprint(contactD)  {'Barr, Ted E': '210-555-1111',  'Board, Bill': '830-222-2222',  'Board, Emory': '830-222-3333',  'Board, Peg': '830-222-3333'}  **Example #18: sorting a dictionary by its key**  >>> # To control sorted printing, use sorted(*dictionary*)  print ("%-15s %s"%("Name", "Phone"))  for name in sorted(contactD):  print ("%-15s %s"%(name, contactD[name]))  Name Phone  Barr, Ted E 210-555-1111  Board, Bill 830-222-2222  Board, Emory 830-222-3333  Board, Peg 830-222-3333  >>> "Board, Bill" in contactD  True  >>> "830-222-2222" in contactD.values()  True |
| **How to sort by the value in a dictionary**  Instead of sorting by the key (e.g., name), let's sort by the value (e.g., phone number).  **for** *key* **in sorted**(*dict*, **key=***dict.***get**):  *doSomething*  If we wanted sorted in descending order, include the argument **reverse=True**.  **for** *key* **in sorted**(*dict*, **key=***dict.***get,** \  **reverse=TRUE**):  *doSomething* | **Example #19: sorting a dictionary by its value**  >>> # Print in descending order by phone number  print ("%-15s %s"%("Name", "Phone"))  for name in sorted(contactD, key=contactD.get, reverse=True):  print ("%-15s %s"%(name, contactD[name]))  Name Phone  Board, Emory 830-222-3333  Board, Peg 830-222-3333  Board, Bill 830-222-2222  Barr, Ted E 210-555-1111 |
| **Assignments**  **Compound Assignments**  **+=, -=, \*=, /=, //=**  **|=, &=**  Notice that Python doesn't provide **++** nor **--.**  **Chain Assignments**  **=** can be used to chain assignments  **Multi-target**  separate the targets with commas | **Example #20: Assignment Operations (compound, chain, multi-target)**  >>> x = 5  x += 10  print(x)  15  >>> z = 5  w = x = y = z # Assign z to y, x, and w  print (w, x, y, z)  5 5 5 5  >>> # interchange values using multi-target  x = 5  y = 10  x,y = y, x  print ("x=", x, "y=", y)  x=10 y= 5  >>> # Suppose fruit is a list  fruit = ["orange", "grape", "apple"]  o, g, a = fruit # unpacks the list and  # assigns "orange" to o,  # "grape" to g, and  # "apple" to a  print("1.", o, g, a)  o, \*rest = fruit # The \* says to give anything else  # to the variable rest. Assigns  # "orange" to o and it assigns  # ["grape", "apple"] to rest  print ("2.", o, rest)  fruit = ["orange", "grape", "apple", "clark"]  one, \*two, three = fruit  # Assigns "orange" to one,  # ["grape", "apple"] to two,  # "clark" to three  print ("3.", one, two, three)  **Output:**  1. orange grape apple  2. orange ['grape', 'apple']  3. orange ['grape', 'apple'] clark |
| **Assignments - Array**   * **Copy reference** via array assignment * **Slice assignment** | **Example #21: Array Assignment**  >>> # Copying a Reference to an Array:  fruit = ["orange", "grape", "apple", "clark"]  profs = fruit  profs[0] = "maynard"  >>> print(fruit)  ["maynard", "grape", "apple", "clark"]  >>> print(profs)  ["maynard", "grape", "apple", "clark"]  **Example #22: Array Slice Assignment**  >>> # Assignment to a slice of an array:  L = [100, 101, 102, 103, 104, 105, 106]  L[2:5] = [22,33,44] # replace items 2, 3, and 4  >>> print (L)  [100, 101, 22, 33, 44, 105, 106]  >>> L[2:5] = [] # remove items 2, 3, and 4  >>> print (L)  [100, 101, 105, 106] |
| **Conditional Statements**  Python has three types of conditional statements.  if-then construct:  if *condExpr* :  *indentedBodyStatements*  if-then-else construct:  if *condExpr* :  *indentedBodyStatements*  else:  *indentedBodyStatements*  if-then-else-if construct:  if *condExpr* :  *indentedBodyStatements*  elif *condExpr* :  *indentedBodyStatements* | **Example #23: if, else, elif**  >>> # if-then  if grade >= 60:  print("you passed")  >>> # if-then-else with nested if-then-else  if command == "WITHDRAWAL":  if dBalance > 0:  dBalance -= dAmount  print("New balance:", dBalance)  else:  print("Insufficient funds:", dAmount)  elif command == "DEPOSIT":  dBalance += dAmount |
| **Conditional Statements - Case**  Python doesn't provide a case construct. | does that  http://www.wackystock.com/details/1084861-clipart-businessman-wearing-a-clothespin-on-his-nose-due-to-smell---royalty-free-vector-illustration-by-dennis-cox-at-wackystock.jpg ? |
| **Iteration - while**  while-loop construct:  while *condExpr* :  *indentedBodyStatements*  Python also has break and continue statements. The break isn't labeled.  **while**  also supports an **else** statement**.** If the while exits due to a false *condExpr*, the else is executed. If a **break** statement causes the termination, the **else** statement does not execute. | **Example #24: while, else, break**  >>> # Example input loop  while True:  print("Please type your name.");  name = input()  if name != "your name":  break  print ("Good morning,", name)  >>> # enter numbers until 0 is entered. Show the sum unless a  # bad number is entered.  num = '1'  sum = 0  while num != '0':  print("Enter a positive number (zero to terminate).")  num = input()  if num.isdecimal() != True:  break  sum += int(num)  else:  print ("Sum is", sum)  only executes else if num != '0' is met |
| **Iteration With Control Variables**  for *controlVar* in range(*begVal,endVal,stepVal*):  *indentedBodyStatements*  The *stepVal* can be positive or negative.  **for** loops also have an optional **else** statement. | **Example #25: Iteration with Control Variables**  >>> # counting from 0 to 4  for i in range (0, 5):  print(i)  print('outside', i)  **Output:**  0  1  2  3  4  outside 4  >>> # counting from 0 to 4 by 2  for i in range (0, 5, 2):  print(i)  print('outside', i)  **Output:**  0  2  4  outside 4  # counting from 5 to 1 by -1  for i in range (5, 0, -1):  print(i)  print('outside', i)  5  4  3  2  1  outside 1 |
| **Is the Python for statement impacted by changes to the control variables?** | **Example #26: Impact on for statement**  >>> # 1 using additional control variable  e = 5  incr = 2  for i in range (0, e, incr):    print (i)  print('outside', i)  **0**  **2**  **4**  **outside 4**  >>> # 2 changing i  e = 5  incr = 2  for i in range (0, e, incr):  print ("in top", i)  i += 1  print ("after", i)  print('outside', i)  **in top 0**  **after 1**  **in top 2**  **after 3**  **in top 4**  **after 5**  **outside 5**  >>> # 3 changing e  e = 5  incr = 2  for i in range (0, e, incr):  print (i)  e = 9  print('outside', i)  **0**  **2**  **4**  **outside 4**  >>> # 4 changing incr  e = 5  incr = 2  for i in range (0, e, incr):  print (i)  incr = 3  print('outside', i)  **0**  **2**  **4**  **outside 4** |
| **Iteration with Control Variables - Based on other Objects**  for *controlVar* in *object*:  *indentedBodyStatements* | **Example #27: Iteration based on other objects**  # 1 simple for in  fruitM = ["apple", "orange", "banana"]  for fruit in fruitM:  print (fruit)  Output:  apple  orange  banana  # 2 adding elements within the for  i = 0  fruitM = ["apple", "orange", "banana"]  fruitM.append("tangerine")  for fruit in fruitM:  print (fruit)  i += 1  if i < 3:  fruitM.append("grape")    print (fruitM)  Output:  **apple**  **orange**  **banana**  **tangerine**  **grape**  **grape**  **['apple', 'orange', 'banana', 'tangerine', 'grape', 'grape']** |
| for *controlVar1, controlVar2* in *listOfTuple*:  *indentedBodyStatements*  If each element is a tuple, you can specify multiple control variables, representing each of the values in the tuple. | **Example #28: Iteration based returning tuples**  contactD = {"Board, Bill": "830-222-2222"  , "Board, Peg": "830-222-3333"  , "Barr, Ted E": "210-555-1111"}  contactD["Board, Emory"] = contactD["Board, Peg"]; #copy Peg's phone to Emory  # access the key and value, calling them name and phone  for name, phone in contactD.items():  print (name, phone)  Output:  Board, Emory 830-222-3333  Board, Bill 830-222-2222  Barr, Ted E 210-555-1111  Board, Peg 830-222-3333 |
| **Continuation of statements**  Some Python statements can be continued to the next line implicitly. This is possible when continuing something that was begun with an open delimiter (e.g. "(", "[", "{"). Otherwise, you can continue to the next line by ending a line with a **backslash**.  \ = continuation | **Example #29: Statement Continuation**  >>> grades = [100, 90, 95, 75, 80,  90, 35]  >>> state = "TX"  vehicleType = "TRUCK"  if state == "TX" \  and vehicleType == "TRUCK":  print("it is") |
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