12. Logical Maneuvers

Topics:
- Loop-Body Returns
- Exceptions
- Assertions
- Type Checking
- Try-Except

Loop-Body Returns

Loop-Body Returns

Another way to terminate a loop.

Uses the fact that in a function, control is passed back to the calling program as soon as a return statement is encountered.

A Problem

Write a function

`MyFind(char,s)`

that returns **`True`** if character **`char`** is in string **`s`** and returns False otherwise.

.

Typical While-Loop Solution

```
def MyFind(char,s):
   k = 0
   while k<len(s) and char!=s[k]:
      k = k+1
   if k==len(s):
      return False
   else:
      return True
```

When the loop ends, if k==len(s) is True, then we never found an instance of char.

While-Loop Solution with a Loop-Body Return

```
def MyFind(char,s):
   k = 0
   while k<len(s):
      if s[k]==char
         return True
      k = k+1
   return False
```

The function “jumps out of the loop” and returns True should it encounter an instance of char. If the loop runs to completion, that means there is no instance of char.

For Loop Solution with a Loop Body `return`

```
def MyFind(char,s):
   for k in range(len(s)):
       if s[k]==char:
          return True
   return False
```

The function "jumps out of the loop" and returns True should it encounter an instance of char. If the loop runs to completion, that means there is no instance of char.

Another For Loop Solution with a Loop Body `return`

```
def MyFind(char,s):
   for c in s:
       if c==char:
          return True
   return False
```

The function "jumps out of the loop" and returns True should it encounter an instance of char. If the loop runs to completion, that means there is no instance of char.

Boolean Variables

Review: Variables and floats

It is possible to assign a float value to a variable:

```
a = 1.3
b = 10.1
c = 3.7
r = -b + math.sqrt(b*b-4*a*c))/(2*a)
```

Review: Variables and ints

It is possible to assign a string value to a variable:

```
m = '7'
d = '4'
y = '1776'
date = m + '/' + d + '/' + y
```

Review: Variables and Booleans

It is possible to assign a boolean value to a variable:

```
L = 1
R = 2
x = 1.3
inside = (L<=x) and (x<=R)
```

Boolean Variables

As the course progresses you will be dealing with logical situations that are increasingly complicated.

Boolean variables are a handy way of keeping track of what is going on.

Example: Leap Year

Gregorian Calendar Rule:

Y is a leap year if it is a century year that is divisible by 400 or a non-century year that is divisible by 4.

Leap years: 1904, 2000, 2016

Not leap years: 1900, 2015

Example: Leap Year

Gregorian Calendar Rule:

Y is a leap year if it is a century year that is divisible by 400 or a non-century year that is divisible by 4.

```
centuryYear = (Y%100==0)
if centuryYear:
    LY = (Y%400==0)
else:
    LY = (Y%4==0)
```

Y is a positive int.

LY is assigned the value True if Y is a leap year and False otherwise.

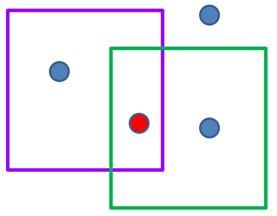
Boolean Functions

Boolean Functions

A function can return a boolean value.

This can be a handy way of encapsulating a complicated computation that culminates in the production of a True value or a False value.

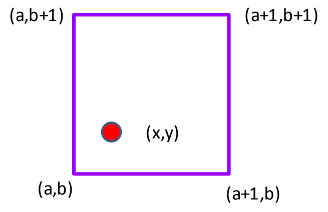
Example: Intersecting Squares



A unit square has side length one.

Given two unit squares and a point, when is the point inside both squares?

Point in a Unit Square



Must have:

a <= x <= a+1

b <= y <= b+1

```
xOK = (a<=x<=a+1)
yOK = (b<=y<=b+1)
```

Point in a Unit Square

```
def inS(a,b,x,y):
    """ Returns True if (x,y) is inside
    the square with vertices (a,b),
    (a+1,b),(a,b+1), and (a+1,b+1).
    Otherwise, returns False."""
    xOK = (a<=x<=a+1)
    yOK = (b<=y<=b+1)
    z = (xOK and yOK)
    return z
```

Using `inS`

```
z2 = inS(a1,b1,x,y) and inS(a2,b2,x,y)
```

z2 is True if and only if (x,y) is inside

(i) the unit square with lower left vertex (a1,b1).

and also

(ii) the unit square with lower left vertex (a2,b2).

Exceptions

Exceptions are errors that occur while your program is running. The program stops running when an exception is "raised."

There are many types of exceptions.

Here are some examples…

`ValueError`

```
>>> t = int('12F')

ValueError: invalid literal for
int() with base 10: '123F'
```

In English:

The int function does not accept a string unless it encodes a number.

`ImportError`

```
>>> from superMath import sqrt

ImportError: No module named
superMath
```

In English:

You cannot import stuff from a nonexistent module or a module that is not in the same working directory

ImportError

```
>>> >>> from math import SquareRoot

ImportError: cannot import name
SquareRoot
```

In English:
the math module does not contain a function named SquareRoot

NameError

```
>>> x = 3
>>> x = y+2

NameError: name 'y' is not defined
```

In English:
The variable y does not exist.

TypeError

```
>>> x = 3
>>> s = 'abc'
>>> t = s/x

TypeError: unsupported operand
type(s) for /: 'str' and 'int'
```

In English:
You cannot divide a string by a number.

TypeError

```
>>> from math import sqrt
>>> x = sqrt('a')

TypeError: a float is required
```

In English:
The square root function requires a number.

ZeroDivisionError

```
>>> x = 3.0/0.0
ZeroDivisionError: float division by
zero
```

In English:
Cannot divide by zero.

Assertions

They enable you to generate exceptions if something is wrong.

A good way to check that your code is doing what it should be doing.

A good way to focus on pre- and post- conditions during the program development phase.

Assertions: How They Work

Syntax:

```
assert  B,S
```

B is a boolean expression .

S is a string.

If B is not true, then string S is printed and an exception is "raised".

Otherwise, nothing is done.

Checking Pre-, Post- Conditions

Typical:

1. At the start of a function body, are the preconditions satisfied?
2. At the end of the function body, does the value returned have the required properties?

Checking Pre-, Post Conditions

```
def sqrt(x):
   """ Returns an approximate
    square root of x in that
   |L*L-x| <= .001

   PreC: x is a positive number.
   """
```

Checking Pre-, Post conditions

```
def sqrt(x):

     assert x>0, 'The sqrt function
          requires a positive argument.'
     L = float(x)
     L = (L+x/L)/2
     L = (L+x/L)/2
     L = (L+x/L)/2
     L = (L+x/L)/2
     assert abs(L*L-x)<=.001,
            'Inaccurate Square Root'
     return L
```

Type Checking

Use **assert** and the function **isinstance**

How isinstance Works

It is a boolean-valued function with two arguments.

```
isinstance(x,int)
```
True if variable x houses an int value
Otherwise, False

```
isinstance(x,float)
```
True if variable x houses a float value
Otherwise, False

```
isinstance(x,str)
```
True if variable x houses a string value
Otherwise, False

Using `isinstance`

Guard against the user passing a string to sqrt:

```
def sqrt(x):
  assert isinstance(x,float) or
         isinstance(x,int),
         print 'x must be type int or
                float'
    :
```

The `Try-except` Construction

A graceful way to handle exceptions

Example: Try-Except

```
try:
    from AintNoMath import sqrt
    print 'AintNoMath.sqrt unavailable'
except ImportError:
    from math import sqrt
    print 'AintNoMath.sqrt is  not
                available'
# Code that uses sqrt...
a = 9; x = sqrt(a); print a,x
```

If the green code triggers an ImportError exception, then the mauve code is executed and "sqrt" comes from the math module. Otherwise sqrt comes from AintNoMath

Try-Except Construction

```
try:
      Code that may generate
      a particular exception

except Name of Exception :
      Code to execute if
      the particular
      exception is found
```

`break`

`break`

Another way to terminate a loop

But it must be used with care for style reasons.

How **break** Works

As soon as a break statement is executed inside a loop body, the loop ends and the next statement after the body is executed.

Example

Compute the smallest **N** so that **N!>10**

```
fact = 1
for N in range(1,10000):
      fact = fact*N
      if fact>10:
          print N
          break
print fact
```

Loop range big enough to ensure we will get a large enough factorial

Recall that 5! = 1 x 2 x 3 x 4 x5

Example

Print the smallest **N** so that **N!>10**

```
fact = 1
for N in range(1,10000):
      fact = fact*N
      if fact>10:
          print N
          break
print fact
```

Bad Style! Have to guess a suitable for-loop range.

While Loop Solution

Compute the smallest **N** so that **N!>10**

```
fact = 1
N = 1
# fact = N!
while fact <=10:
      N = N+1
      fact = fact*N
print fact
```

A Good Example of **break** Usage

Consider the following problem.

A user enters an integer N from the keyboard and Python is to display the value of N!

Recall: 5! = 1x2x3x4x5 = 120

Use **math.factorial(N)**

A Good Example of **break** Usage

Possible issue.

When we use **math.factorial(N)**, the value of **N** must be nonnegative.

What if the user inputs -5?

Would like to say, “try again”

A Good Example of break Usage

```
while True:
   N = raw_input('Enter pos int: ')
   N = int(N)
   if N>=0
      break
   else:
      print 'N must be nonnegative'
print math.factorial(N)
```

Keep iterating until a nonnegative int is obtained

Another Issue

If the user doesn't enter a string of digits then the int statement will crash the program:

```
N = raw_input('Enter pos int: ')
N = int(N)
```

This brings up the challenge of "exceptions" and "exception handling."

A ValueError Exception

```
>>> int('12F')
ValueError: invalid literal for int()
    with base 10: '12F'
```

Exception a.k.a. run time error

Challenge

Is there a way we can keep soliciting keyboard input until the user enters a string of numbers?

Don't want the program to terminate because of a ValueError.

The Try-except Construction

A graceful way to handle exceptions

Example Showing Try-Except

```
from math import factorial

while True:
    n = raw_input('Enter an integer: ')
    try:
        n = int(n)
        break
    except ValueError:
        print 'Invalid input. Try again.'

m = factorial(n)
print m
```

How It Works

```
from math import factorial

while True:
   n = raw_input('Enter an integer: ')
   try:
       n = int(n)
       break
   except ValueError:
       print 'Invalid input. Try again.'

print factorial(n
```

If int(n) in the green block triggers a ValueError exception, then control passes to the cyan block. A message is printed and the loop continues

How It Works

```
from math import factorial

while True:
   n = raw_input('Enter an integer: ')
   try:
       n = int(n)
       break
   except ValueError:
       print 'Invalid input. Try again.'

print factorial(n)
```

If int(n) does not trigger a ValueError exception, then the break is executed and the loop is over and control passes to the print factorial(n) line