Introduction to Programming
CS101

Spring 2012

Lecture #3

Grading

Practice points:

- 100 points for lecture attendance;
- 100 points for lab work;
- 200 points for homework.

Students need to collect at least 320 practice points.
Definitely NO BONUS Homework!

Theory points:

- 100 points for midterm exam;
- 100 points for final exam.

The grade is determined by the theory points only.
The practice points over 320 are qualification for grading.

On-line class review

- site: `http://e-star.kaist.ac.kr`
- id: your portal id
- password: your portal password

Review

What we have learned so far:

- function definitions
- function calls
- method calls
- for loops
- while loops
- conditionals

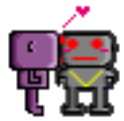
Objects

Programs work with data. Every piece of data in a Python program is called an object.

Objects can be very small (the number 3) or very large (a digital photograph).

Every object has a type. The type determines what you can do with an object.

The Python Zoo:
Imagine there is a zoo inside your Python interpreter.
Every time you create an object, an animal is born.
What an animal can do depends on the type (kind) of animal:
birds can fly, fish can swim, elephants can lift weights, etc.
When an animal is no longer used, it dies (disappears).



Making objects

You can create objects as follows:

Numbers: Simply write them:

```
13
3.14159265
-5
3 + 6j
```

 complex number

Strings: (a piece of text)

Write text between quotation marks (" and ’ are both okay):

```
"CS101 is wonderful"
’The instructor said: "Well done!" and smiled’
```

Booleans: (truth values)

Write `True` or `False`.

Making more objects

Complicated objects are made by calling functions that create them:

```
from cs1robots import *
Robot()
```

```
from cs1media import *
load_picture("photos/geowi.jpg")
```

A tuple object is an object that contains other objects.
To create a tuple, write objects separated by commas (usually in parenthesis):

```
(3, 2.5, 7)
("red", "yellow", "green")
(20100001, "Hong Gildong")
```

Different animals: Types

Every object has a type. The type determines what the object can do, and what you can do with the object. For instance, you can add two numbers, but you cannot add two robots.

The Python interpreter can tell you the type of an object:

```
>>> type(3)
<type 'int'>
>>> type(3.1415)
<type 'float'>
>>> type("CS101 is fantastic")
<type 'str'>
>>> type(3 + 7j)
<type 'complex'>
>>> type(True)
<type 'bool'>
```

Integer number: int

Floating point number: float

String: str

Complex number: complex

Boolean: bool

More types

Types of more complicated objects:

```
>>> type(Robot())
<class 'cs1robots.Robot'>
>>> type( (3, -1.5, 7) )
<type 'tuple'>
>>> type( load_picture("geowi.jpg") )
<class 'cs1media.Picture'>
```

Some object types are built into the Python language:

`<type 'xxx'>`

Other object types are defined by Python modules:

`<class 'xxx'>`

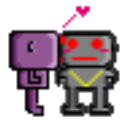
Names

Objects can be given a name:

```
message = "CS101 is fantastic"
n = 17
hubo = Robot()
pi = 3.14159265358979 31
finished = True
img = load_picture("geowi.jpg")
```

We call a statement like `n = 17` an assignment, because the name `n` is assigned to the object `17`.

In the Python zoo, the name is a sign board on the animal's cage.



Variable names

The rules for variable and function names:

- A name consists of letters, digits, and the underscore `_`.
- The first character of a name is a letter.
- The name cannot be a keyword such as `def`, `if`, `else`, or `while`.
- Upper case and lower case are different: `Pi` is not the same as `pi`.

Good:

```
my_message = "CS101 is fantastic"
a13 = 13.0
```

Bad:

```
more@ = "illegal character"
13a = 13.0
def = "Definition 1"
```

Variables

Names are often called variables, because the meaning of a name is variable: the same name can be assigned to different objects during a program:

```
n = 17
n = "Seventeen"
n = 17.0
```

In the Python zoo, this means that the sign board is moved from one animal to a different animal.

The object assigned to a name is called the value of the variable. The value can change over time.

To indicate that a variable is empty, we use the special object `None` (of type `NoneType`):

```
m = None
```

Methods

What objects can do depends on the type of object: a bird can fly, a fish can swim.
Objects provide methods to perform these actions.

The methods of an object are used through dot-syntax:

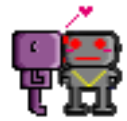
```
>>> hubo = Robot()
>>> hubo.move()
>>> hubo.turn_left()

>>> img = load_picture()
>>> print img.size()
(58, 50)
>>> img.show()

>>> b = "banana"
>>> print b.upper()
BANANA
```

width and height in pixels

display the image



Operators

For numbers, we use the operators `+`, `-`, `*`, `/`, `//`, `%`, and `**`.

```
>>> 2**16
65536
```

`a ** b` $= a^b$

```
>>> 7 % 3
1
```

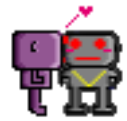
Remainder after division

`//` is integer division (division without fractional part):

```
>>> 13.0 // 4.0
3.0
```

Warning: In Python 2, the division operator `/` works like `//` if both objects are `int` objects. This has been fixed in Python 3:

```
>>> 9 / 7
1
>>> from __future__ import division
>>> 9 / 7
1.2857142857142858
```



Expressions

An expression is a combination of objects, variables, operators, and function calls:

```
3.0 * (2 ** 15 - 12 / 4) + 4 ** 3
```

The operators have precedence as in mathematics:

1. exponentiation `**`
2. multiplication and division `*`, `/`, `//`, `%`
3. addition and subtraction `+`, `-`

When in doubt, use parentheses!

$\frac{a}{2\pi}$ is not `a/2*pi`.

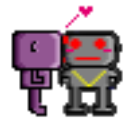
Use `a/(2*pi)` or `a/2/pi`.

All operators also work for complex numbers.

String expressions

The operators + and * can be used for strings:

```
>>> "Hello" + "CS101"
'HelloCS101'
>>> "CS101 " * 8
'CS101 CS101 CS101 CS101 CS101 CS101 CS101 CS101 '
```



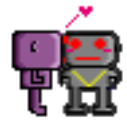
Boolean expressions

A boolean expression is an expression whose value has type `bool`. They are used in `if` and `while` statements.

The operators `==`, `!=`, `>`, `<`, `<=`, and `>=` return boolean values.

```
>>> 3 < 5
True
>>> 27 == 14
False
>>> 3.14 != 3.14
False
>>> 3.14 >= 3.14
True
>>> "Cheong" < "Choe"
True
>>> "3" == 3
False
```

Equality—don't confuse with `=`



Logical operators

The keywords `not`, `and`, and `or` are logical operators:

```
not True == False
not False == True

False and False == False
False and True == False
True and False == False
True and True == True

False or False == False
False or True == True
True or False == True
True or True == True
```

Careful: if the second operand is not needed, Python does not even compute its value.

Tuples

A tuple is an object that contains other objects:

```
position = (3.14, -5, 7.5)
profs = ("Yoonjoon Lee", "In-Young Ko",
         "Sukyoung Ryu")
```

A tuple is a single object of type `tuple`:

```
>>> print position, type(position)
(3.14, -5, 7.5)  <type 'tuple'>
```

We can "unpack" tuples:

```
x, y, z = position
```

Packing and unpacking in one line:

```
a, b = b, a
```

Colors

Colors are often represented as a tuple with three elements that specify the intensity of red, green, and blue light:

```
red = (255, 0, 0)
blue = (0, 0, 255)
white = (255, 255, 255)
black = (0, 0, 0)
yellow = (255, 255, 0)
purple = (128, 0, 128)

from cs1media import *
img = create_picture(100, 100, purple)
img.show()
img.set_pixels(yellow)
img.show()
```

Digital images

A digital image of width `w` and height `h` is a rectangular matrix with `h` rows and `w` columns:

$0, 0$	$1, 0$	$2, 0$	$3, 0$	$4, 0$
$0, 1$	$1, 1$	$2, 1$	$3, 1$	$4, 1$
$0, 2$	$1, 2$	$2, 2$	$3, 2$	$4, 2$

We access pixels using their `x` and `y` coordinates.
`x` is between 0 and `w-1`, `y` is between 0 and `h-1`.

```
>>> img.get(250, 188)
(101, 104, 51)
>>> img.set(250, 188, (255, 0, 0))
```

red, green, blue triple

For loops

A for-loop assigns integer values to a variable:

```
for i in range(4):
  print i
```

prints 0, 1, 2, 3.

```
>>> for i in range(7):
>>>   print "*" * i


*
**
***
****
*****
******
```

Negative of a photo

```
from cs1media import *

img = load_picture("../photos/geowi.jpg")
w, h = img.size()
for y in range(h):
  for x in range(w):
    r, g, b = img.get(x, y)
    r, g, b = 255 - r, 255 - g, 255 - b
    img.set(x, y, (r, g, b))
img.show()
```

Black & white photo

```
from cs1media import *
threshold = 100
white = (255, 255, 255)
black = (0, 0, 0)

img = load_picture("../photos/yuna1.jpg")
w, h = img.size()
for y in range(h):
  for x in range(w):
    r, g, b = img.get(x, y)
    v = (r + g + b) // 3      # average of r,g,b
    if v > threshold:
        img.set(x, y, white)
    else:
        img.set(x, y, black)
img.show()
```

Objects with two names

The same object can have more than one name:

```
hubo = Robot("yellow")
hubo.move()
ami = hubo
ami.turn_left()
hubo.move()

hubo = Robot("blue")
hubo.move()
ami.turn_left()
ami.move()
```