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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:

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```
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3.14159265
-5
3 + 6j
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Strings: (a piece of text)

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

```
"CS101 is wonderful"
’The instructor said: "Well done!" and smiled’
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Write text between quotation marks (" and ’ are both allowed):

```
"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")
```

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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.

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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() )
<class 'cs1media.Picture'>
```

More types

Types of more complicated objects:

```
>>> type(Robot())
<class 'cs1robots.Robot'>
>>> type( (3, -1.5, 7) )
<type 'tuple'>
>>> type( load_picture() )
<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 = 3.1415926535897931
finished = True
img = load_picture("geowi.jpg")
```

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Objects can be given a name:

```
message = "CS101 is fantastic"
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We call a statement like `n = 17` an assignment, because the name `n` is assigned to the object `17`.

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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`.

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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:

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n = 17
n = "Seventeen"
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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

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width and height in pixels

display the image

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(58, 50)
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>>> b = "banana"
>>> print b.upper()
BANANA
```

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Operators

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

```
>>> 2**16
65536
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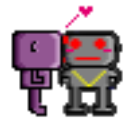
Remainder after division

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

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



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1
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`//` is integer division (division without fractional part):

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>>> 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:

```
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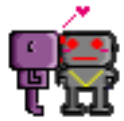
When in doubt, use parentheses!



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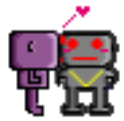
$\frac{a}{2\pi}$ is not `a/2*pi`.



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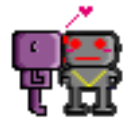
Use `a/(2*pi)` or `a/2/pi`.



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All operators also work for complex numbers.

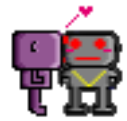
String expressions

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.



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
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```

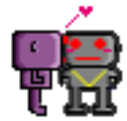

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```

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:

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position = (3.14, -5, 7.5)
profs = ("Otfried Cheong", "Taisook Han",
         "Jaehyuk Huh")
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>>> print position, type(position)
(3.14, -5, 7.5)  <type 'tuple'>
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Packing and unpacking in one line:

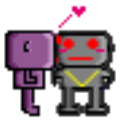
```
a, b = b, a
```

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)

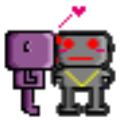
from cs1media import *
img = create_picture(100, 100, purple)
img.show()
img.set_pixels(yellow)
img.show()
```



Digital images

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

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



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

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

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red, green, blue triple

For loops

A for-loop assigns integer values to a variable:

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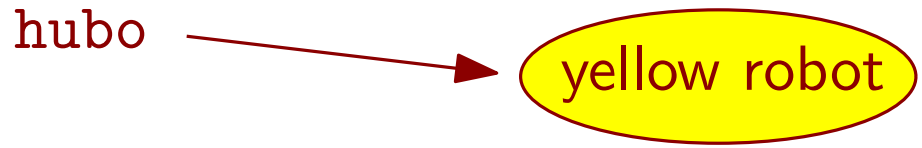

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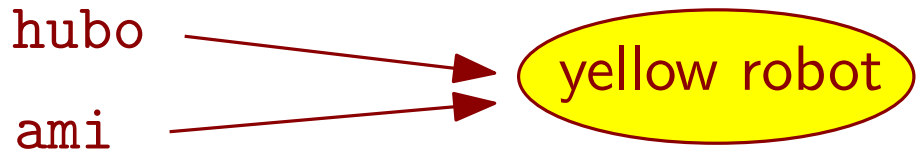

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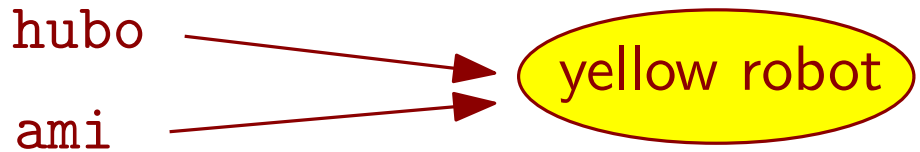


```
hubo = Robot("lightblue")
hubo.move()
ami.turn_left()
ami.move()
```

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