Introduction to Python Programming

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Introduction to Python

John Strickler

Version 1.0, November 2021

Table of Contents

About this course

Welcome!

- We're glad you're here
- Class has hands-on labs for nearly every chapter
- Please make a name tent

Instructor name:

Instructor e-mail:

Have Fun!

Classroom etiquette

- Noisemakers off
- No phone conversations
- Come and go quietly during class.

Please turn off cell phone ringers and other noisemakers.

If you need to have a phone conversation, please leave the classroom.

We're all adults here; feel free to leave the classroom if you need to use the restroom, make a phone call, etc. You don't have to wait for a lab or break, but please try not to disturb others.

IMPORTANT	Please do not bring killer rabbits to class. They might maim, dismember, or otherwise disturb your fellow students.

Course Outline

Half-Day 1

Chapter 1 Getting Started
Chapter 2 Flow Control
Chapter 3 Errors and Exception Handling

Half-Day 2

Chapter 4 Array Types
Chapter 5 Working with Files

Half-Day 3

Chapter 6 Dictionaries and sets
Chapter 7 Functions
Chapter 8 Sorting

Half-Day 4

Chapter 9 Regular Expressions
Chapter 10 Sorting

NOTE	The actual schedule varies with circumstances. The last day may include *ad hoc* topics requested by students

Student files

You will need to load some files onto your computer. The files are in a compressed archive. When you extract them onto your computer, they will all be extracted into a directory named **py3introx**.

What's in the files?

py3introx contains data and other files needed for the exercises
py3introx/EXAMPLES contains the examples from the course manuals.
py3introx/ANSWERS contains sample answers to the labs.

WARNING	The student files do not contain Python itself. It will need to be installed separately. This has probably already been done for you.

Extracting the student files

Windows

Open the file **py3introx.zip**. Extract all files to your desktop. This will create the folder **py3introx**.

Non-Windows (includes Linux, OS X, etc)

Copy or download **py3introx.tar.gz** to your home directory. In your home directory, type

```
tar xzvf py3introx.tar.gz
```

This will create the **py3introx** directory under your home directory.

Examples

Nearly all examples from the course manual are provided in the EXAMPLES subdirectory.

It will look like this:

Example

cmd_line_args.py

```
#!/usr/bin/env python

import sys   ①

print(sys.argv) ②

name = sys.argv[1]  ③
print("name is", name)
```

① Import the **sys** module

② Print all parameters, including script itself

③ Get the first actual parameter

cmd_line_args.py Fred

```
['/Users/jstrick/curr/courses/python/examples3/cmd_line_args.py', 'Fred']
name is Fred
```

Lab Exercises

- Relax – the labs are not quizzes
- Feel free to modify labs
- Ask the instructor for help
- Work on your own scripts or data
- Answers are in py3introx/ANSWERS

Appendices

- Appendix A: Where Do I Go from here?
- Appendix B: Python Bibliography
- Appendix C: String Formatting

Chapter 1: Getting Started

Objectives

- Using variables
- Understanding dynamic typing
- Working with text
- Working with numbers
- Writing output to the screen
- Getting command line parameters
- Reading keyboard input

Using variables

- Variables are created when assigned to
- May hold any type of data
- Names are case sensitive
- Names may be any length

Variables in Python are created by assigning a value to them. They are created and destroyed as needed by the interpreter. Variables may hold any type of data, including string, numeric, or Boolean. The data type is dynamically determined by the type of data assigned.

Variable names are composed of letters, digits, and underscores, and may not start with a digit. Any Unicode character that corresponds to a letter or digit may also be used.

Variable names are case sensitive, and may be any length. `Spam`, `SPAM`, and `spam` are three different variables.

A variable *must* be assigned a value. A value of `None` (null) may be assigned if no particular value is needed. It is good practice to make variable names consistent. The Python style guide Pep 8 (https://www.python.org/dev/peps/pep-0008) suggests:

```
    all_lower_case_with_underscores
```

Example

```
quantity = 5
historian = "AJP Taylor"
final_result = 123.456
program_status = None
```

Keywords and Builtins

- Keywords are reserved
- Using a keyword as a variable is a syntax error
- 72 builtin functions
- Builtins *may* be overwritten (but it's not a big deal)

Python keywords may not be used as names. You cannot say `class = 'Sophomore'`.

On the other hand, any of Python's 72 builtin functions, such as `len()` or `int()` may be used as identifiers, but that will overwrite the builtin's functionality, so you shouldn't do that.

TIP Be especially careful not to use `dir`, `file`, `id`, `len`, `max`, `min`, and `sum` as variable names, as these are all builtin function names.

Python 3 Keywords

```
False     class     finally   is         return
None      continue  for       lambda     try
True      def       from      nonlocal   while
and       del       global    not        with
as        elif      if        or         yield
assert    else      import    pass
break     except    in        raise
```

Table 1. Builtin functions

abs()	float()*	object()*
all()	format()	oct()
any()	frozenset()*	open()
ascii()	getattr()	ord()
bin()	globals()	pow()
bool()*	hasattr()	print()
bytearray()*	hash()	property()*
bytes()*	help()	quit()
callable()	hex()	range()*
chr()	id()	repr()
classmethod()*	input()	reversed()*
compile()	int()*	round()
complex()*	isinstance()	set()*
copyright()	issubclass()	setattr()
credits()	iter()	slice()*
delattr()	len()	sorted()
dict()*	license()	staticmethod()*
dir()	list()*	str()*
divmod()	locals()	sum()
enumerate()*	map()*	super()*
eval()	max()	tuple()*
exec()	memoryview()*	type()*
exit()	min()	vars()
filter()*	next()	zip()*

*These functions are class constructors

Variable typing

- Python is strongly and dynamically typed
- Type based on assigned value

Python is a strongly typed language. That means that whenever you assign a value to a name, it is given a *type*. Python has many types built into the interpreter, such as `int`, `str`, and `float`. There are also many packages providing types, such as `date`, `re`, or `urllib`.

Certain operations are only valid with the appropriate types.

WARNING Python does not automatically convert strings to numbers or numbers to strings.

Strings

- All strings are Unicode
- String literals
  - Single-delimited (single-line only)
  - Triple-delimited (can be multi-line)
- Use single-quote or double-quote symbols
- Backslashes introduce *escape sequences*
- Strings can be raw (escape sequences not interpreted)

All python strings are Unicode strings. They can be initialized with several types of string literals. Strings support escape characters, such as \t and \n, for non-printable characters.

Single-delimited string literals

- Enclosed in pair of single or double quotes
- May not contain embedded newlines
- Backslash is treated specially.

Single-delimited strings are enclosed in a pair of single or double quotes.

Escape codes, which start with a backslash, are interpreted specially. This makes it possible to include control characters such as tab and newline in a string.

Single-delimited strings may not contain an embedded newline; that is, they may not be spread over multiple physical lines. They may contain \n, the escape code for a new line.

There is no difference in meaning between single and double quotes. The term "single-quoted" in the Python documentation means that there is one quote symbol at each end of the sting literal.

TIP Adjacent string literals are concatenated.

Example

```
name = "John Smith"
title = 'Grand Poobah'
color = "red"
size = "large"
poem = "I think that I will never see\na poem lovely as a tree"
```

Triple-delimited string literals

- Used for multi-line strings
- Can have embedded quote characters
- Used for docstrings

Triple-delimited strings use three double or single quotes at each end of the text. They are the same as single-delimited strings, except that individual single or double quotes are left alone, and that embedded newlines are preserved.

Triple-delimited text is used for text containing literal quotes as well as documentation and boiler-plate text.

Example

```
name = """James Earl "Jimmy" Carter"""
warning = """
Professional driver on closed course
Do not attempt
Your mileage may vary
Ask your doctor if Python is right for you
"""

query = '''
from contacts
where zipcode = '90210'
order by lname
'''
```

NOTE The quotes on both ends of the text must match – use either all single or all double quotes, whether it's a normal or a triple-delimited literal.

Raw string literals

- Start with **r**
- Do not interpret backslashes

If a literal starts with **r** before the quote marks, then it is a raw string literal. Backslashes are not interpreted.

This is handy if the text to be output contains literal backslashes, such as many regular expression patterns, or Windows path names.

Example

```
pat = r"\w+\s+\w+"
loc = r"c:\temp"
msg = r"please put a newline character (\n) after each line"
```

This is similar to the use of single quotes in some other languages.

Unicode characters

- Use \uXXXX to specify non-ASCII Unicode characters
- XXXX is Unicode value in hex
- \N\{*NAME*} also OK

Unicode characters may be embedded in literal strings. Use the Unicode value for the character in the form \uXXXX, where XXXX is the hex version of the character's code point.

You can also specify the Unicode character name using the syntax \N{name}.

For code points above FFFF, use \UXXXXXXXX (note capital "U").

Raw strings accept the \u or \U notation, but do not accept \N{}.

See http://www.unicode.org/charts for lists of Unicode character names

Example

unicode.py

```
#!/usr/bin/env python

print('26\u00B0')  ①
print('26\N{DEGREE SIGN}')  ②
print(r'26\u00B0\n')  ③
print()

print('we spent \u20ac1.23M for an original C\u00e9zanne') ④
print("Romance in F\u266F Major")
print()

data = ['\U0001F95A', '\U0001F414']  ⑤
print("unsorted:", data)
print("sorted:", sorted(data))
```

① Use \uXXXX where XXXX is the Unicode value in hex

② The Unicode entity name can be used, enclosed in \N{}

③ \N{} is not expanded in raw strings

④ More examples.

⑤ Python answers the age-old question.

unicode.py

```
26°
26°
26\u00B0\n

we spent €1.23M for an original Cézanne
Romance in F♯ Major

unsorted: ['🥚', '🐔']
sorted: ['🐔', '🥚']
```

Table 2. Escape Sequences

Sequence	Description
newline	Embedded newline
\\	Backslash
\'	Single quote
\"	Double quote
\a	BEL
\b	BACKSPACE
\f	FORMFEED
\n	LINEFEED
\N{name}	Unicode named code point *name*
\r	Carriage Return
\t	TAB
\uxxxx	16-bit Unicode code point
\Uxxxxxxxx	32-bit Unicode code point (for values above 0xFFFF)
\ooo	Char with octal ASCII value ooo
\xhh	Character with hex ASCII value hh

String operators and methods

- Methods called from string objects
- Some builtin functions apply to strings
- Strings cannot be modified in-place
- Modified copies of strings are returned

Python has a rich set of operators and methods for manipulating strings.

Methods are called from string objects (variables) using "dot notation" – *STR*.method(). Some builtin functions are not called from strings, such as **len()**.

Strings are *immutable* – they can not be changed (modified in-place). Many string functions return a modified copy of the string.

Use + (plus) to concatenate two strings.

String methods may be chained. That is, you can call a string method on the string returned by another method.

If you need a substring function, that is provided by the **slice** operation in the **Array Types** chapter.

String methods may be called on literal strings as well

```
s = 'Barney Rubble'
print(s.upper())
print(s.count('b'))
print(s.lower().count('b'))

print(",".join(some_list))
print("abc".upper())
```

Example

strings.py

```
#!/usr/bin/env python

a = "My hovercraft is full of EELS"

print("original:", a)
print("upper:", a.upper())
print("lower:", a.lower())
print("swapcase:", a.swapcase()) ①
print("title:", a.title())  ②
print("e count (normal):", a.count('e'))
print("e count (lower-case):", a.lower().count('e')) ③
print("found EELS at:", a.find('EELS'))
print("found WOLVERINES at:", a.find('WOLVERINES')) ④

b = "graham"
print("Capitalized:", b.capitalize()) ⑤
```

① Swap upper and lower case

② All words are capitalized

③ Methods can be chained. The next method is called on the object returned by the previous method.

④ Returns -1 if substring not found

⑤ Capitalizes first character of string, only if it is a letter

strings.py

```
original: My hovercraft is full of EELS
upper: MY HOVERCRAFT IS FULL OF EELS
lower: my hovercraft is full of eels
swapcase: mY HOVERCRAFT IS FULL OF eels
title: My Hovercraft Is Full Of Eels
e count (normal): 1
e count (lower-case): 3
found EELS at: 25
found WOLVERINES at: -1
Capitalized: Graham
```

String Methods

Table 3. string methods

Method	Description
S.capitalize()	Return a capitalized version of S, i.e. make the first character have upper case and the rest lower case.
S.casefold()	Return a version of S suitable for caseless comparisons.
S.center(width[, fillchar])	Return S centered in a string of length width. Padding is done using the specified fill character (default is a space)
S.count(sub, [, start[, end]])	Return the number of non-overlapping occurrences of substring sub. Optional arguments start and end specify a substring to search.
S.encode(encoding='utf-8', errors='strict')	Encode S using the codec registered for encoding. Default encoding is 'utf-8'. errors may be given to set a different error handling scheme. Default is 'strict' meaning that encoding errors raise a UnicodeEncodeError. Other possible values are 'ignore', 'replace' and 'xmlcharrefreplace' as well as any other name registered with codecs.register_error that can handle UnicodeEncodeErrors.
S.endswith(suffix[, start[, end]])	Return True if S ends with the specified suffix, False otherwise. With optional start, test S beginning at that position. With optional end, stop comparing S at that position. suffix can also be a tuple of strings to try.
S.expandtabs(tabsize=8)	Return a copy of S where all tab characters are expanded using spaces. If tabsize is not given, a tab size of 8 characters is assumed.
S.find(sub[, start[, end]])	Return the lowest index in S where substring sub is found, such that sub is contained within S[start:end]. Optional arguments start and end are interpreted as in slice notation. Returns -1 on failure.
S.format(*args, **kwargs)	Return a formatted version of S, using substitutions from args and kwargs. The substitutions are identified by braces ('{' and '}').
S.format_map(mapping)	Return a formatted version of S, using substitutions from mapping. The substitutions are identified by braces ('{' and '}').
S.index(sub[, start[, end]])	Like find() but raise ValueError when the substring is not found.
S.isalnum()	Return True if all characters in S are alphanumeric and there is at least one character in S, False otherwise.
S.isalpha()	Return True if all characters in S are alphabetic and there is at least one character in S, False otherwise.
S.isdecimal()	Return True if there are only decimal characters in S, False otherwise.

Method	Description
S.isdigit()	Return True if all characters in S are digits and there is at least one character in S, False otherwise.
S.isidentifier()	Return True if S is a valid identifier according to the language definition.
S.islower()	Return True if all cased characters in S are lowercase and there is at least one cased character in S, False otherwise.
S.isnumeric()	Return True if there are only numeric characters in S, False otherwise.
S.isprintable()	Return True if all characters in S are considered printable in repr() or S is empty, False otherwise.
S.isspace()	Return True if all characters in S are whitespace and there is at least one character in S, False otherwise.
S.istitle()	Return True if S is a titlecased string and there is at least one character in S, i.e. upper- and titlecase characters may only follow uncased characters and lowercase characters only cased ones. Return False otherwise.
S.isupper()	Return True if all cased characters in S are uppercase and there is at least one cased character in S, False otherwise.
S.join(iterable)	Return a string which is the concatenation of the strings in the iterable. The separator between elements is the string from which join() is called
S.ljust(width[, fillchar])	Return S left-justified in a Unicode string of length width. Padding is done using the specified fill character (default is a space).
S.lower()	Return a copy of the string S converted to lowercase.
S.lstrip([chars])	Return a copy of the string S with leading whitespace removed. If chars is given and not None, remove characters in chars instead.
S.partition(sep)	Search for the separator sep in S, and return the part before it, the separator itself, and the part after it. If the separator is not found, return S and two empty strings.
S.replace(old, new[, count])	Return a copy of S with all occurrences of substring old replaced by new. If the optional argument count is given, only the first count occurrences are replaced.
S.rfind(sub[, start[, end]])	Return the highest index in S where substring sub is found, such that sub is contained within S[start:end]. Optional arguments start and end are interpreted as in slice notation. Return -1 on failure.
S.rindex(sub[, start[, end]])	Like rfind() but raise ValueError when the substring is not found.
S.rjust(width[, fillchar])	Return S right-justified in a string of length width. Padding is done using the specified fill character (default is a space).

Method	Description
S.rpartition(sep)	Search for the separator sep in S, starting at the end of S, and return the part before it, the separator itself, and the part after it. If the separator is not found, return two empty strings and
S.rsplit(sep=None, maxsplit=-1)	Return a list of the words in S, using sep as the delimiter string, starting at the end of the string and working to the front. If maxsplit is given, at most maxsplit splits are done. If sep is not specified, any whitespace string is a separator.
S.rstrip([chars])	Return a copy of the string S with trailing whitespace removed. If chars is given and not None, remove characters in chars instead.
S.split(sep=None, maxsplit=-1)	Return a list of the words in S, using sep as the delimiter string. If maxsplit is given, at most maxsplit splits are done. If sep is not specified or is None, any whitespace string is a separator and empty strings are removed from the result.
S.splitlines([keepends])	Return a list of the lines in S, breaking at line boundaries. Line breaks are not included in the resulting list unless keepends is given and true.
S.startswith(prefix[, start[, end]])	Return True if S starts with the specified prefix, False otherwise. With optional start, test S beginning at that position. With optional end, stop comparing S at that position. prefix can also be a tuple of strings to try.
S.strip([chars])	Return a copy of the string S with leading and trailing whitespace removed. If chars is given and not None, remove characters in chars instead.
S.swapcase()	Return a copy of S with uppercase characters converted to lowercase and vice versa.
S.title()	Return a titlecased version of S, i.e. words start with title case characters, all remaining cased characters have lower case.
S.translate(table)	Return a copy of the string S, where all characters have been mapped through the given translation table, which must be a mapping of Unicode ordinals to Unicode ordinals, strings, or None. Unmapped characters are left untouched. Characters mapped to None are deleted.
S.upper()	Return a copy of S converted to uppercase.
S.zfill(width)	Pad a numeric string S with zeros on the left, to fill a field of the specified width. The string S is never truncated.

Numeric literals

- Four kinds of numeric objects
  - Booleans
  - Integers
  - Floats
  - Complex numbers
- Integer literals can be decimal, octal, or hexadecimal
- Floating point can be traditional or scientific notation

Boolean

Boolean values can be 1 (true) or 0 (false). The keywords True and False can be used to represent these values, as well.

Integers

Integers can be specified as decimal, octal, or hexadecimal. Prefix the number with 0o for octal, 0x for hex, or 0b for binary. Integers are signed, and can be arbitrarily large.

Floats

Floating point integers may be specified in traditional format or in scientific notation.

Complex Numbers

Complex numbers may be specified by adding J to the end of the number.

Example

numeric.py

```
#!/usr/bin/env python

a = 5
b = 10
c = 20.22
d = 0o123        ①
e = 0xdeadbeef   ②
f = 0b10011101   ③

print("a, b, c", a, b, c)
print("a + b", a + b)
print("a + c", a + c)
print("d", d)
print("e", e)
print("f", f)
```

① Octal

② Hex

③ Binary

numeric.py

```
a, b, c 5 10 20.22
a + b 15
a + c 25.22
d 83
e 3735928559
f 157
```

Math operators and expressions

- Many built-in operators and expressions
- Operations between integers and floats result in floats

Python has many math operators and functions. Later in this course we will look at some libraries with extended math functionality.

Most of the operators should look familiar; a few may not:

Division

Division (/) always returns a float result.

Assignment-with-operation

Python supports C-style assignment-with-operation. For instance, `x += 5` adds 5 to variable x. This works for nearly any operator in the format:

```
VARIABLE OP=VALUE        e.g. x += 1
```

is equivalent to

```
VARIABLE = VARIABLE OP VALUE    e.g. x = x + 1
```

Exponentiation

To raise a number to a power, use the ** (exponentiation) operator or the pow() function.

Floored Division

Using the floored division operator //, the result is always rounded down to the nearest whole number.

Order of operations

*P*lease *E*xcuse *M*y *D*ear *A*unt *S*ally!

Parentheses, Exponents, Multiplication or Division, Addition or Subtraction (but use parentheses for readability)

Example

math_operators.py

```
#!/usr/bin/env python

x = 22
x += 10  ①

y = 5
y *= 3  ①

print("x:", x)
print("y:", y)

print("2 ** 16", 2 ** 16)

print("x / y", x / y)
print("x // y", x // y)  ②
```

① Same as x = x + 1, y = y * 3, *etc*.

② Returns floored result (rounded down to nearest whole number)

math_operators.py

```
x: 32
y: 15
2 ** 16 65536
x / y 2.1333333333333333
x // y 2
```

NOTE	Python does not have the ++ and — (post-increment and post-decrement) operators common to many languages derived from C.

Table 4. Python Math Operators and Functions

Operator or Function	What it does
x + y	sum of x and y
x – y	difference of x and y
x * y	product of x and y
x / y	quotient of x and y
x // y	(floored) quotient of x and y
x % y	remainder of x / y
-x	x negated
+x	x unchanged
abs(x)	absolute value or magnitude of x
int(x)	x converted to integer
float(x)	x converted to floating point
complex(re,im)	a complex number with real part re, imaginary part im. im defaults to zero.
c.conjugate()	conjugate of the complex number c
divmod(x, y)	the pair (x // y, x % y)
pow(x, y) x ** y	x raised to the power y

Converting among types

- No automatic conversion between numbers and strings
- Builtin functions
  - int() convert string or number to integer
  - float() convert string or number to float
  - str() convert anything to string
  - bool() convert anything to bool
  - list() convert any iterable to a list
  - tuple() convert any iterable to a tuple
  - set() convert any iterable to a set
  - dict() convert any iterable of pairs to a dict

Python is dynamically typed; if you assign a number to a variable, it will raise an error if you use it with a string operator or function; likewise, if you assign a string, you can't use it with numeric operators.

There are built-in functions to do these conversions. Use int(s) to convert string s to an integer. Use str(n) to convert anything to a string, and so forth.

If the string passed to int() or float() contains characters other than digits or minus sign, a runtime error is raised. Leading or trailing whitespace, however, are ignored. Thus " 123 " is OK, but "123ABC" is not.

Writing to the screen

- Use print() function
- Adds spaces between arguments (by default)
- Adds newline at end (by default)
- Use **sep** parameter for alternate separator
- Use **end** parameter for alternate ending

To output text to the screen, use the print function. It takes a list of one or more arguments, and writes them to the screen. By default, it puts a space between them and ends with a newline.

Two special named arguments can modify the default behavior. The *sep* parameter specifies what is output between items, and *end* specifies what is written after all the arguments.

Example

print_examples.py

```
#!/usr/bin/env python

print("Hello, world")
print("#------------------------")

print("Hello,", end=' ')  ①
print("world")
print("#------------------------")

print("Hello,", end=' ')
print("world", end='!')  ②
print("#------------------------")

x = "Hello"
y = "world"

print(x, y)  ③
print("#------------------------")

print(x, y, sep=', ')  ④
print("#------------------------")

print(x, y, sep='')  ⑤
print("#------------------------")
```

① Print space instead of newline at the end

② Print bang instead of newline at end

③ Item separator is space instead of comma

④ Item separator is comma + space

⑤ Item separator is empty string

print_examples.py

```
Hello, world
#------------------------
Hello, world
#------------------------
Hello, world!#------------------------
Hello world
#------------------------
Hello, world
#------------------------
Helloworld
#------------------------
```

String Formatting

- Use the .format() method
- Syntax: "template".format(VALUES)
- Placeholders: {left_curly}Num:FlagsWidthType{right_curly}

Strings have a format() method which allows variables and other objects to be embedded in strings and optionally formatted. Parameters to format() are numbered starting with 0, and are formatted by the correspondingly numbered placeholders in the string. However, if no numbers are specified, the placeholders will be auto-numbered from left to right, starting with 0. You cannot mix number and non-numbered placeholders in the same format string.

A placeholder looks like this: {} (for auto-numbering), or {*n*} (for manual numbering). To add formatting flags, follow the parameter number (if any) with a colon, then the type and other flags. You can also used named parameters, and specify the name rather than the parameter index.

Builtin types to not need to have the type specified, but you may specify the width of the formatted value, the number of decimal points, or other type-specific details.

For instance, {0} will use default formatting for the first parameter; {2:04d} will format the third parameter as an integer, padded with zeroes to four characters wide.

There are many more ways of using format(); this discussion describes some of the basics.

To include literal braces in the string, double them: {{ }}.

See [string_formatting] for details on formatting.

TIP For even more information, check out the PyDoc topic FORMATTING, or section 6.1.3.1 [ttps://docs.python.org/3/library/string.html#format-specification-mini-language] of The Python Standard Library documentation, the **Format Specification Mini-Language**.

NOTE Python 3.6 added *f-strings*, which will further simplify embedding variables in strings. See Pep 0498 [https://www.python.org/dev/peps/pep-0498/]

Example

string_formatting.py

```
#!/usr/bin/env python

name = "Tim"
count = 5
avg = 3.456
info = 2093

print("Name is [{:<10s}]".format(name))  ①
print("Name is [{:>10s}]".format(name))  ②
print("count is {:03d} avg is {:.2f}".format(count, avg))  ③

print("info is {0} {0:d} {0:o} {0:x}".format(info))  ④
print("info is {0} {0:d} {0:#o} {0:#x}".format(info))  ⑤

print("${:,d}".format(38293892))  ⑥

print("It is {temp} in {city}".format(city='Orlando', temp=85))  ⑦
```

① < means left justify (default for non-numbers), 10 is field width, s formats a string

② > means right justify

③ .2f means round a float to 2 decimal points

④ d is decimal, o is octal, x is hex

⑤ # means add 0x, 0o, etc.

⑥ , means add commas to numeric value

⑦ parameters can be selected by name instead of position :b ***string_formatting.py***

```
Name is [Tim       ]
Name is [       Tim]
count is 005 avg is 3.46
info is 2093 2093 4055 82d
info is 2093 2093 0o4055 0x82d
$38,293,892
It is 85 in Orlando
```

Legacy String Formatting

- Use the % operator
- Syntax: "template" % (VALUES)
- Similar to printf() in C

Prior to Python 2.6, the % operator was used for formatting. It returns a string that results from filling in a template string with placeholders in specified formats. :

```
%flagW.Ptype
```

where W is width, P is precision (max width or # decimal places)

The placeholders are similar to standard formatting, but are positional rather than numbered, and are specified with a percent sign, rather than braces.

If there is only one value to format, the value does not need parentheses.

WARNING	Legacy string formatting is deprecated as of Python 3.1, and may be removed in the future. It supports most of the same formatting features as the new style.

Table 5. Legacy formatting types

d,i	decimal integer
o	octal integer
u	unsigned decimal integer
x,X	hex integer (lower, UPPER case)
e,E	scientific notation (lower, UPPER case)
f,F	floating point
g,G	autochoose between e and f
c	character
r	string (using repr() method)
s	string (using str() method)
%	literal percent sign

Table 6. Legacy formatting flags

-	left justify (default is right justification)
#	use alternate format
0	left-pad number with zeros
+	precede number with + or -
(blank)	precede positive number with blank, negative with -

Example

string_formatting_legacy.py

```
#!/usr/bin/env python

name = "Tim"
count = 5
avg = 3.456
info = 2093

print("Name is [%-10s]" % name)   ①
print("Name is [%10s]" % name)   ②
print("count is %03d avg is %.2f" % (count, avg)) ③

print("info is %d %o %x" % (info, info, info))      ④
print("info is %d %o %x" % ((info,) * 3))    ⑤

print("info is %d %#oo %#x" % (info, info, info))    ⑥
```

① Dash means left justify string

② Right justify (default)

③ Argument to % is either a single variable or a tuple

④ Arguments must be repeated to be used more than once

⑤ Obscure way of doing the same thing Note: (x,) is singleton tuple

⑥ # means add 0x, 0o, etc.

string_formatting_legacy.py

```
Name is [Tim       ]
Name is [       Tim]
count is 005 avg is 3.46
info is 2093 4055 82d
info is 2093 4055 82d
info is 2093 0o4055o 0x82d
```

Command line parameters

- Use the **argv** list that is part of the sys module
- sys must be imported
- Element 0 is the script name itself

To get the command line parameters, use the list sys.argv. This requires importing the sys module. To access elements of this list, use square brackets and the element number. The first element (index 0) is the name of the script, so sys.argv[1] is the first argument to your script.

Example

sys_argv.py

```
#!/usr/bin/env python

import sys

print(sys.argv)
print()

name = sys.argv[1]  ①
print("name is", name)
```

① First command line parameter

sys_argv.py Gawain

```
['/Users/jstrick/curr/courses/python/examples3/sys_argv.py', 'Gawain']

name is Gawain
```

TIP If you use an index for a non-existent parameter, an error will be raised and your script will exit. In later chapters you will learn how to check the size of a list, as well as how to trap the error.

Reading from the keyboard

- Use input()
- Provides a prompt string
- Use int() or float() to convert input to numeric values

To read a line from the keyboard, use input(). The parameter is a prompt string, and it returns the text that was entered. You can use int() or float() to convert the input to an integer or a floating-point number.

TIP If you use int() or float() to convert a string, a fatal error will be raised if the string contains any non-numeric characters or any embedded spaces. Leading and trailing spaces will be ignored.

Example

keyboard_input.py

```
#!/usr/bin/env python

name = input("What is your name: ")
quest = input("What is your quest? ")
print(name, "seeks", quest)

raw_num = input("Enter number: ")  ①
num = int(raw_num)  ②

print("2 times", num, "is ", 2 * num)
```

① input is always a string

② convert to numbers as needed

keyboard_input.py

```
What is your name:  Sir Lancelot
What is your quest?  the Grail
Sir Lancelot seeks the Grail
Enter number:  5
2 times 5 is  10
```

Chapter 1 Exercises

Exercise 1-1 (c2f.py)

Write a Celsius to Fahrenheit converter. Your script should prompt the user for a Celsius temperature, then print out the Fahrenheit equivalent.

To run the script at a command prompt:

```
python c2f.py
```

(or run from PyCharm/VS Code/Spyder etc)

The program prompts the user, and the user enters the temperature to be converted.

The formula is `F = ((9 * C) / 5 ) + 32`. Be sure to convert the user-entered value into a float.

Test your script with the following values: 100, 0, 37, -40

Exercise 1-2 (c2f_batch.py)

Create another C to F converter. This time, your script should take the Celsius temperature from the command line and output the Fahrenheit value.

To run the script at a command prompt:

```
python c2f_batch.py 100
```

(or run from PyCharm/VS Code/Spyder etc)

Test with the values from **c2f.py**.

These two programs should be identical, except for the input.

Exercise 1-3 (string_fun.py)

Write a script to prompt the user for a full name. Once the name is read in, do the following:

- Print out the name as-is
- Print the name in upper case
- Print the name in title case
- Print the number of occurrences of 'j'
- Print the length of the name
- Print the position (offset) of "jacob" in the string

Run the program, and enter "john jacob jingleheimer schmidt"

Chapter 2: Flow Control

Objectives

- Understanding how code blocks are delimited
- Implementing conditionals with the if statement
- Learning relational and Boolean operators
- Exiting a while loop before the condition is false

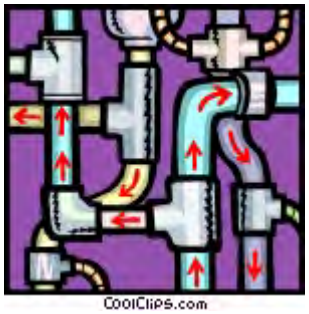
About flow control

- Controls order of execution
- Conditionals and loops
- Uses Boolean logic

Flow control means being able to conditionally execute some lines of code, while skipping others, depending on input, or being able to repeat some lines of code.

In Python, the flow control statements are if, while, and for.

NOTE Another kind of flow control is a function, which goes off to some other code, executes it, and returns to the current location. We'll cover functions in a later chapter.



What's with the white space?

- Blocks defined by indenting
- No braces or BEGIN-END keywords
- Enforces what good programmers do anyway
- Be consistent (suggested indent is 4 spaces)

One of the first things that most programmers learn about Python is that whitespace is significant. This might seem wrong to many; however, you will find that it was a great decision by Guido, because it enforces what programmers should be doing anyway.

It's very simple: After a line introducing a block structure (if statement, for/while loop, function definition, or class definition), all indented statements under the line are part of the block. Blocks may be nested, as in any language. The nested block has more indentation. A block ends when the interpreter sees a line with less indentation than the previous line.

Example

```
if value > 6:           start if statement
    print(value)        body of if

linecount = 0
for line in config:         start for loop
    if line.startswith("global"):   start if (body of for)
        print(line)         body of if
    linecount += 1          back to body of for
```

TIP Be consistent with indenting – use either all tabs or all spaces. Most editors can be set to your preference. (Guido suggests using 4 spaces).

if and elif

- The basic conditional statement is if
- Use else for alternatives
- elif provides nested if-else

The basic conditional statement in Python is if expression:. If the expression is true, then all statements in the block will be executed.

Example

```
if EXPR:
    statement
    statement
    ...
```

The expression does not require parentheses; only the colon at the end of the if statement is required.

In Python, a value is *false* if it is numeric zero, an empty container (string, list, tuple, dictionary, set, etc.), the builtin **False** object, or **None**. All other values are *true*.

The values **True** and **False** are predefined to have values of 1 and 0, respectively.

If an else statement is present, statements in the else block will be executed when the if statement is false.

For nested if-then, use the elif statement, which combines an if with an else. This is useful when the decision has more than two possibilities.

True and **False** are case-sensitive.

WARNING

Don't say

```
if x == True:
```

unless you really mean that x could only be 0 (False) or 1 (True). Just say

```
if x:
```

Conditional Expressions

- Used for simple if-then-else conditions

When you have a simple if-then-else condition, you can use the conditional expression. If the condition is true, the first expression is returned; otherwise the second expression is returned.

```
value = expr1 if condition else expr2
```

This is a shortcut for

```
if condition:
    value = expr1
else:
    value = expr2
```

Example

```
print(long_message if DEBUGGING else short_message)

audience = 'j' if is_juvenile(curr_book_rec) else 'a'

file_mode = 'a' if APPEND_MODE else 'w'
```

Relational Operators

- Compare two objects
- Overloaded for different types of data
- Numbers cannot be compared to strings

```
==    !=    <     >     >=    <=
```

Python has six relational operators, implementing equality or greater than/less than comparisons. They can be used with most types of objects. All relational operators return **True** or **False**.

NOTE	Strings and numbers cannot be compared using any of the greater-than or less-than operators. Also, no string is equal to any number.

Example

if_else.py

```
#!/usr/bin/env python

raw_temp = input("Enter the temperature: ")
temp = int(raw_temp)

if temp < 76:
    print("Don't go swimming")

num = int(input("Enter a number: "))
if num > 1000000:
    print(num, "is a big number")
else:
    print("your number is", num)

raw_hour = input("Enter the hour: ")
hour = int(raw_hour)

if hour < 12:
    print("Good morning")
elif hour < 18:                    ①
    print("Good afternoon")
elif hour < 23:
    print("Good evening")
else:
    print("You're up late")
```

① **elif** is short for "else if", and always requires an expression to check

if_else.py

```
Enter the temperature:  50
Don't go swimming
Enter a number:  9999999
9999999 is a big number
Enter the hour:  8
Good morning
```

Boolean operators

- Combine Boolean values
- Can be used with any expressions
- Short-circuit
- Return last operand evaluated

The Boolean operators **and**, **or**, and **not** may be used to combine Boolean values. These do not need to be of type bool – the values will be converted as necessary.

These operators short-circuit; they only evaluate the right operand if it is needed to determine the value. In the expression **a() or b()**, if **a()** returns True, **b()** is not called.

The return values of Boolean operators are the last operand evaluated. **4 and 5** returns 5. **0 or 4** returns 4.

Table 7. Boolean Operators

Expression	Value
AND	
12 and 5	5
5 and 12	12
0 and 12	0
12 and 0	0
"" and 12	""
12 and ""	""
OR	
12 or 5	12
5 or 12	5
0 or 12	12
12 or 0	12
"" or 12	12
12 or ""	12

while loops

- Loop while some condition is **True**
- Used for getting input until user quits
- Used to create services (AKA daemons)

```
while EXPR:
    statement
    statement
    ...
```

The **while** loop is used to execute code as long as some expression is true. Examples include reading input from the keyboard until the users signals they are done, or a network server looping forever with a **while True:** loop.

In Python, the **for** loop does much of the work done by a while loop in other languages.

NOTE	Unlike many languages, reading a file in Python generally uses a **for** loop.

Alternate ways to exit a loop

- **break** exits loop completely
- **continue** goes to next iteration

Sometimes it is convenient to exit a loop without regard to the loop expression. The **break** statement exits the smallest enclosing loop.

This is used when repeatedly requesting user input. The loop condition is set to **True**, and when the user enters a specified value, the break statement is executed.

Other times it is convenient to abandon the current iteration and go back to the top of the loop without further processing. For this, use the **continue** statement.

Example

while_loop_examples.py

```
#!/usr/bin/env python

print("Welcome to ticket sales\n")

while True:  ①
    raw_quantity = input("Enter quantity to purchase (or q to quit): ")
    if raw_quantity == '':
        continue  ②
    if raw_quantity.lower() == 'q':
        print("goodbye!")
        break  ③

    quantity = int(raw_quantity)  # could validate via try/except
    print("sending {} ticket(s)".format(quantity))
```

① Loop "forever"

② Skip rest of loop; start back at top

③ Exit loop

while_loop_examples.py

```
Welcome to ticket sales

Enter quantity to purchase (or q to quit):  4
sending 4 ticket(s)
Enter quantity to purchase (or q to quit):
Enter quantity to purchase (or q to quit):  2
sending 2 ticket(s)
Enter quantity to purchase (or q to quit):  q
goodbye!
```

Chapter 2 Exercises

Exercise 2-1 (c2f_loop.py)

Redo **c2f.py** to repeatedly prompt the user for a Celsius temperature to convert to Fahrenheit and then print. If the user just presses **Return**, go back to the top of the loop. Quit when the user enters "q".

TIP

read in the temperature, test for "q" or "", and only then convert the temperature to a float.#

Exercise 2-2 (guess.py)

Write a guessing game program. You will think of a number from 1 to 25, and the computer will guess until it figures out the number. Each time, the computer will ask "Is this your number? "; You will enter "l" for too low, "h" for too high, or "y" when the computer has got it. Print appropriate prompts and responses.

TIP

1. Start with max_val = 26 and min_val = 0
2. guess is always (max_val + min_val)//2 *Note integer division operator*
3. If current guess is too high, next guess should be halfway between lowest and current guess, and we know that the number is less than guess, so set max_val = guess
4. If current guess is too low, next guess should be halfway between current and maximum, and we know that the number is more than guess, so set min_val = guess

TIP

If you need more help, see next page for pseudocode. When you get it working for 1 to 25, try it for 1 to 1,000,000. (Set max_value to 1000001).

Exercise 2-3 (guessx.py)

Get the maximum number from the command line *or* prompt the user to input the maximum, or both (if no value on command line, then prompt).

Pseudocode for guess.py

```
MAXVAL=26
MINVAL=0
while TRUE
    GUESS = int((MAXVAL + MINVAL)/2)
    prompt "Is your guess GUESS? "
    read ANSWER
    if ANSWER is "y"
        PRINT "I got it!"
        EXIT LOOP
    if ANSWER is "h"
        MAXVAL=GUESS
    if ANSWER is "l"
        MINVAL=GUESS
```

Chapter 3: Errors and Exception Handling

Objectives

- Understanding syntax errors
- Handling exceptions with try-except-else-finally
- Learning the standard exception objects

Syntax errors

- Generated by the parser
- Cannot be trapped

Syntax errors are generated by the Python parser, and cause execution to stop (your script exits). They display the file name and line number where the error occurred, as well as an indication of where in the line the error occurred.

Because they are generated as soon as they are encountered, syntax errors may not be handled.

Example

```
  File "<stdin>", line 1
    for x in bargle
                  ^
SyntaxError: invalid syntax
```

TIP When running in interactive mode, the filename is <stdin>.

Exceptions

- Generated when runtime errors occur
- Usually fatal if not handled

Even if code is syntactically correct, errors can occur. A common run-time error is to attempt to open a non-existent file. Such errors are called exceptions, and cause the interpreter to stop with an error message.

Python has a hierarchy of builtin exceptions; handling an exception higher in the tree will handle any children of that exception.

TIP Custom exceptions can be created by sub-classing the Exception object.

Example

exception_unhandled.py

```
#!/usr/bin/env python

x = 5
y = "cheese"

z = x + y  ①
```

① Adding a string to an int raises **TypeError**

exception_unhandled.py

```
Traceback (most recent call last):
  File "exception_unhandled.py", line 6, in <module>
    z = x + y  ①
TypeError: unsupported operand type(s) for +: 'int' and 'str'
```

Handling exceptions with try

- Use try/except clauses
- Specify expected exception

To handle an exception, put the code which might generate an exception in a try block. After the try block, you must specify a except block with the expected exception. If an exception is raised in the try block, execution stops and the interpreter looks for the exception in the except block. If found, it executes the except block and execution continues; otherwise, the exception is treated as fatal and the interpreter exits.

Example

exception_simple.py

```
#!/usr/bin/env python

try:  ①
    x = 5
    y = "cheese"
    z = x + y
    print("Bottom of try")

except TypeError as err:    ②
    print("Naughty programmer! ", err)

print("After try-except")  ③
```

① Execute code that might have a problem

② Catch the expected error; assign error object to **err**

③ Get here whether or not exception occurred

exception_simple.py

```
Naughty programmer!  unsupported operand type(s) for +: 'int' and 'str'
After try-except
```

Handling multiple exceptions

- Use a tuple of exception names, but with single argument

If your try clause might generate more than one kind of exception, you can specify a tuple of exception types, then the variable which will hold the exception object.

Example

exception_multiple.py

```
#!/usr/bin/env python

try:
    x = 5
    y = "cheese"
    z = x + y
    f = open("sesame.txt")
    print("Bottom of try")

except (IOError, TypeError) as err:  ①
    print("Naughty programmer! ", err)
```

① Use a tuple of 2 or more exception types

exception_multiple.py

```
Naughty programmer!  unsupported operand type(s) for +: 'int' and 'str'
```

Handling generic exceptions

- Use **Exception**
- Specify except with no exception list
- Clean up any uncaught exceptions

As a shortcut, you can specify **Exception** or an empty exception list. This will handle any exception that occurs in the try block.

Example

exception_generic.py

```
#!/usr/bin/env python

try:
    x = 5
    y = "cheese"
    z = x + y
    f = open("sesame.txt")
    print("Bottom of try")

except Exception as err: ①
    print("Naughty programmer! ", err)
```

① Will catch *any* exception

exception_generic.py

```
Naughty programmer!  unsupported operand type(s) for +: 'int' and 'str'
```

Ignoring exceptions

- Use the **pass** statement

Use the **pass** statement to do nothing when an exception occurs

Because the except clause must contain some code, the pass statement fulfills the syntax without doing anything.

Example

exception_ignore.py

```
#!/usr/bin/env python

try:
    x = 5
    y = "cheese"
    z = x + y
    f = open("sesame.txt")
    print("Bottom of try")

except(TypeError, IOError): ①
    pass
```

① Catch exceptions, and do nothing

exception_ignore.py

```
_no output_
```

This is probably a bad idea…

Using else

- executed if no exceptions were raised
- not required
- can make code easier to read

The last except block can be followed by an else block. The code in the else block is executed only if there were no exceptions raised in the try block. Exceptions in the else block are not handled by the preceding except blocks.

The else lets you make sure that some code related to the try clause (and before the finally clause) is only run if there's no exception, without trapping the exception specified in the except clause.

```
try:
    something_that_can_throw_ioerror()
except IOError as e:
    handle_the_IO_exception()
else:
# we don't want to catch this IOError if it's raised
    something_else_that_throws_ioerror()
finally:
    something_we_always_need_to_do()
```

Example

exception_else.py

```
#!/usr/bin/env python

numpairs = [(5, 1), (1, 5), (5, 0), (0, 5)]

total = 0

for x, y in numpairs:
    try:
        quotient = x / y
    except Exception as err:
        print("uh-oh, when y = {}, {}".format(y, err))
    else:
        total += quotient  ①
print(total)
```

① Only if no exceptions were raised

exception_else.py

```
uh-oh, when y = 0, division by zero
5.2
```

Cleaning up with finally

- Executed whether or not exception occurs
- Code executed whether or not exception raised
- Code runs even if **exit()** called
- For cleanup

A **finally** block can be used in addition to, or instead of, an **except** block. The code in a **finally** block is executed whether or not an exception occurs. The **finally** block is executed after the **try**, **except**, and **else** blocks.

What makes **finally** different from just putting statements after try-except-else is that the **finally** block will execute even if there is a **return()** or **exit()** in the **except** block.

The purpose of a **finally** block is to clean up any resources left over from the **try** block. Examples include closing network connections and removing temporary files.

Example

exception_finally.py

```
#!/usr/bin/env python

try:
    x = 5
    y = 37
    z = x + y
    print("z is", z)
except TypeError as err:    ①
    print("Caught exception:", err)
finally:
    print("Don't care whether we had an exception")  ②

print()

try:
    x = 5
    y = "cheese"
    z = x + y
    print("Bottom of try")
except TypeError as err:
    print("Caught exception:", err)
finally:
    print("Still don't care whether we had an exception")
```

① Catch **TypeError**

② Print whether **TypeError** is caught or not

exception_finally.py

```
z is 42
Don't care whether we had an exception

Caught exception: unsupported operand type(s) for +: 'int' and 'str'
Still don't care whether we had an exception
```

The Standard Exception Hierarchy (Python 3.7)

```
BaseException
 +-- SystemExit
 +-- KeyboardInterrupt
 +-- GeneratorExit
 +-- Exception
      +-- StopIteration
      +-- StopAsyncIteration
      +-- ArithmeticError
      |    +-- FloatingPointError
      |    +-- OverflowError
      |    +-- ZeroDivisionError
      +-- AssertionError
      +-- AttributeError
      +-- BufferError
      +-- EOFError
      +-- ImportError
      |    +-- ModuleNotFoundError
      +-- LookupError
      |    +-- IndexError
      |    +-- KeyError
      +-- MemoryError
      +-- NameError
      |    +-- UnboundLocalError
      +-- OSError
      |    +-- BlockingIOError
      |    +-- ChildProcessError
      |    +-- ConnectionError
      |    |    +-- BrokenPipeError
      |    |    +-- ConnectionAbortedError
      |    |    +-- ConnectionRefusedError
      |    |    +-- ConnectionResetError
      |    +-- FileExistsError
      |    +-- FileNotFoundError
      |    +-- InterruptedError
      |    +-- IsADirectoryError
      |    +-- NotADirectoryError
      |    +-- PermissionError
      |    +-- ProcessLookupError
      |    +-- TimeoutError
      +-- ReferenceError
      +-- RuntimeError
      |    +-- NotImplementedError
      |    +-- RecursionError
      +-- SyntaxError
      |    +-- IndentationError
```

```
      |         +-- TabError
      +-- SystemError
      +-- TypeError
      +-- ValueError
      |    +-- UnicodeError
      |         +-- UnicodeDecodeError
      |         +-- UnicodeEncodeError
      |         +-- UnicodeTranslateError
```

Chapter 3 Exercises

Exercise 3-1 (c2f_loop_safe.py)

Rewrite c2f_loop.py to handle the error that occurs if the user enters non-numeric data. The script should print a message and keep going if an error occurs.

Exercise 3-2 (c2f_batch_safe.py)

Rewrite c2f_batch.py to handle the ValueError that occurs if sys.argv[1] is not a valid number.

Chapter 4: Array Types

Objectives

- Using single and multidimensional lists and tuples
- Indexing and slicing sequential types
- Looping over sequences
- Tracking indices with enumerate()
- Using range() to get numeric lists
- Transforming lists

About Array Types

- Array types
  - str
  - bytes
  - list
  - tuple
- Common properties of array types
  - Same syntax for indexing/slicing
  - Share some common methods and functions
  - All can be iterated over with a for loop

Python provides many data types for working with multiple values. Some of these are array types. These hold values in a sequence, such that they can be retrieved by a numerical index.

A str is an array of characters. A bytes object is array of bytes.

All array types may be indexed in the same way, retrieving a single item or a slice (multiple values) of the sequence.

Array types have some features in common with other container types, such as dictionaries and sets. These other container types will be covered in a later chapter.

All array types support iteration over their elements with a for loop.

Example

typical_arrays.py

```
#!/usr/bin/env python

fruits = ['apple', 'cherry', 'orange', 'kiwi', 'banana', 'pear', 'fig']
name = "Eric Idle"
knight = 'King', 'Arthur', 'Britain'

print(fruits[3])  ①
print(name[2])  ②
print(knight[1])  ③
```

typical_arrays.py

```
kiwi
i
Arthur
```

Lists

- Array of objects
- Create with **list()** or [ ]
- Add items with append(), extend(), or insert
- Remove items with del, pop(), or remove()

A list is one of the fundamental Python data types. Lists are used to store multiple values. The values may be similar – all numbers, all user names, and so forth; they may also be completely different. Due to the dynamic nature of Python, a list may hold values of any type, including other lists.

Create a list with the **list()** class or a pair of square brackets. A list can be Initialized with a comma-separated list of values.

Table 8. List Methods (note L represents a list)

Method	Description
del L[i]	delete element at index i (keyword, not function)
L.append(x)	add single value x to end of L
L.count(x)	return count of elements whose value is x
L.extend(*iter*)	individually add elements of *iter* to end of L
L.index(x) L.index(x, i) L.index(x, i, j)	return index of first element whose value is x (after index i, before index j)
L.insert(i, x)	insert element x at offset i
L.pop() L.pop(i)	remove element at index i (default -1) from L and return it
L.remove(x)	remove first element of L whose value is x
L.clear()	remove all elements and leave the list empty
L.reverse()	reverses L in place
L.sort() L.sort(key=func)	sort L in place – func is function to derive key from one element

Example

creating_lists.py

```
#!/usr/bin/env python

list1 = list()  ①
list2 = ['apple', 'banana', 'mango']  ②
list3 = []  ③
list4 = 'apple banana mango'.split()  ④

print("list1:", list1)
print("list2:", list2)
print("list3:", list3)
print("list4:", list4)

print("list2[0]:", list2[0])  ⑤
print("list4[2]:", list4[2])  ⑥

print("list4[-1]:", list4[-1])  ⑦
```

① Create new empty list

② Initialize list

③ Create new empty list

④ Create list of strings with less typing

⑤ First element of **list2**

⑥ Third element of **list4**

⑦ *Last* element of **list4**

creating_lists.py

```
list1: []
list2: ['apple', 'banana', 'mango']
list3: []
list4: ['apple', 'banana', 'mango']
list2[0]: apple
list4[2]: mango
list4[-1]: mango
```

Indexing and slicing

- Use brackets for index
- Use slice for multiple values
- Same syntax for strings, lists, and tuples

Python is very flexible in selecting elements from a list. All selections are done by putting an index or a range of indices in square brackets after the list's name.

To get a single element, specify the index (0-based) of the element in square brackets:

```
foo =  [ "apple", "banana", "cherry", "date", "elderberry",
   "fig","grape" ]

foo[1]  the 2nd element of list foo -- banana
```

To get more than one element, use a slice, which specifies the beginning element (inclusive) and the ending element (exclusive):

```
foo[2:5]    foo[2], foo[3], foo[4] but NOT foo[5] □ cherry, date, elderberry
```

If you omit the starting index of a slice, it defaults to 0:

```
foo[:5] foo[0], foo[1], foo[2], foo[3], foo[4] □ apple,banana,cherry, date, elderberry
```

If you omit the end element, it defaults to the length of the list.

```
foo[4:] foo[4], foo[5], foo[6] □ elderberry, fig, grape
```

A negative offset is subtracted from the length of the list, so -1 is the last element of the list, and -2 is the next-to-the-last element of the list, and so forth:

```
foo[-1] foo[len(foo)-1] or foo[6] □ grape
foo[-3] foo[len(foo)-3] or foo[4] □ elderberry
```

The general syntax for a slice is

```
s[start:stop:step]
```

which means all elements s[N], where

```
start <= N < stop,
```

and start is incremented by step

> **TIP** Remember that start is **IN**clusive but stop is **EX**clusive.

Example

indexing_and_slicing.py

```
#!/usr/bin/env python

pythons = ["Idle", "Cleese", "Chapman", "Gilliam", "Palin", "Jones"]

characters = "Roger", "Old Woman", "Prince Herbert", "Brother Maynard"

phrase = "She turned me into a newt"

print("pythons:", pythons)
print("pythons[0]", pythons[0])  ①
print("pythons[5]", pythons[5])  ②
print("pythons[0:3]", pythons[0:3])  ③
print("pythons[2:]", pythons[2:])  ④
print("pythons[:2]", pythons[:2])  ⑤
print("pythons[1:-1]", pythons[1:-1])  ⑥
print("pythons[0::2]", pythons[0::2])  ⑦
print("pythons[1::2]", pythons[1::2])  ⑧

pythons[3] = "Innes"
print("pythons:", pythons)
print()

print("characters", characters)
print("characters[2]", characters[2])
print("characters[1:]", characters[1:])

# characters[2] = "Patsy"  # ERROR -- can't assign to tuple
print()
print("phrase", phrase)
print("phrase[0]", phrase[0])
print("phrase[-1]", phrase[-1])  ⑨
print("phrase[21:25]", phrase[21:25])
print("phrase[21:]", phrase[21:])
print("phrase[:10]", phrase[:10])
print("phrase[::2]", phrase[::2])
```

① First element

② Sixth element

③ First 3 elements

④ Third element through the end

⑤ First 2 elements

⑥ Second through next-to-last element

⑦ Every other element, starting with first

⑧ Every other element, starting with second

⑨ Last element

indexing_and_slicing.py

```
pythons: ['Idle', 'Cleese', 'Chapman', 'Gilliam', 'Palin', 'Jones']
pythons[0] Idle
pythons[5] Jones
pythons[0:3] ['Idle', 'Cleese', 'Chapman']
pythons[2:] ['Chapman', 'Gilliam', 'Palin', 'Jones']
pythons[:2] ['Idle', 'Cleese']
pythons[1:-1] ['Cleese', 'Chapman', 'Gilliam', 'Palin']
pythons[0::2] ['Idle', 'Chapman', 'Palin']
pythons[1::2] ['Cleese', 'Gilliam', 'Jones']
pythons: ['Idle', 'Cleese', 'Chapman', 'Innes', 'Palin', 'Jones']

characters ('Roger', 'Old Woman', 'Prince Herbert', 'Brother Maynard')
characters[2] Prince Herbert
characters[1:] ('Old Woman', 'Prince Herbert', 'Brother Maynard')

phrase She turned me into a newt
phrase[0] S
phrase[-1] t
phrase[21:25] newt
phrase[21:] newt
phrase[:10] She turned
phrase[::2] Setre eit  et
```

Iterating through a sequence

- use a **for** loop
- works with lists, tuples, strings, or any other iterable
- Syntax

```
for var ... in iterable:
    statement
    statement
    ...
```

To iterate through the values of a list, use the **for** statement. The variable takes on each value in the sequence, and keeps the value of the last item when the loop has finished.

To exit the loop early, use the break statement. To skip the remainder of an iteration, and return to the top of the loop, use the continue statement.

for loops can be used with any iterable object.

TIP	The loop variable retains the last value it was set to in the loop even after the loop is finished. (If the loop is in a function, the loop variable is local; otherwise, it is global).

Example

iterating_over_arrays.py

```
#!/usr/bin/env python

my_list = ["Idle", "Cleese", "Chapman", "Gilliam", "Palin", "Jones"]
my_tuple = "Roger", "Old Woman", "Prince Herbert", "Brother Maynard"
my_str = "She turned me into a newt"

for p in my_list:  ①
    print(p)
print()

for r in my_tuple:  ②
    print(r)
print()

for ch in my_str:  ③
    print(ch, end=' ')
print()
```

① Iterate over elements of list

② Iterate over elements of tuple

③ Iterate over characters of string

iterating_over_arrays.py

```
Idle
Cleese
Chapman
Gilliam
Palin
Jones

Roger
Old Woman
Prince Herbert
Brother Maynard

S h e  t u r n e d  m e  i n t o  a  n e w t
```

Tuples

- Designed for "records" or "structs"
- Immutable (read-only)
- Create with comma-separated list of objects
- Use for fixed-size collections of related objects
- Indexing, slicing, etc. are same as lists

Python has a second array type, the **tuple**. It is something like a list, but is immutable; that is, you cannot change values in a tuple after it has been created.

A tuple in Python is used for "records" or "structs" — collections of related items. You do not typically iterate over a tuple; it is more likely that you access elements individually, or *unpack* the tuple into variables.

Tuples are especially appropriate for functions that need to return multiple values; they can also be good for passing function arguments with multiple values.

While both tuples and lists can be used for any data, there are some conventions.

- Use a list when you have a collection of similar objects.
- Use a tuple when you have a collection of related, but dissimilar objects.

In a tuple, the position of elements is important; in a list, the position is not important.

For example, you might have a list of dates, where each date was contained in a month, day, year tuple.

To specify a one-element tuple, use a trailing comma; to specify an empty tuple, use empty parentheses.

```
result = 5,
result = ()
```

TIP	Parentheses are not needed around a tuple unless the tuple is nested in a larger data structure.

Example

creating_tuples.py

```
#!/usr/bin/env python

birth_date = 1901, 5, 5

server_info = 'Linux', 'RHEL', 5.2, 'Melissa Jones'

latlon = 35.99, -72.390

print("birth_date:", birth_date)
print("server_info:", server_info)
print("latlon:", latlon)
```

creating_tuples.py

```
birth_date: (1901, 5, 5)
server_info: ('Linux', 'RHEL', 5.2, 'Melissa Jones')
latlon: (35.99, -72.39)
```

TIP

To specify a one-element tuple, use a trailing comma, otherwise it will be interpreted as a single object:

```
color = 'red',
```

Iterable Unpacking

- Copy elements to variables
- Works with any array-like object
- More readable than numeric indexing

If you have a tuple like this:

```
my_date = 8, 1, 2014
```

You can access the elements with

```
print(my_date[0], my_date[1], my_date[2])
```

It's not very readable though. How do you know which is the month and which is the day?

A better approach is *unpacking*, which is simply copying a tuple (or any other iterable) to a list of variables:

```
month, day, year = my_date
```

Now you can use the variables and anyone reading the code will know what they mean. This is really how tuples were designed to be used.

Example

iterable_unpacking.py

```
#!/usr/bin/env python

values = ['a', 'b', 'c']

x, y, z = values  ①

print(x, y, z)
print()

people = [
    ('Bill', 'Gates', 'Microsoft'),
    ('Steve', 'Jobs', 'Apple'),
    ('Paul', 'Allen', 'Microsoft'),
    ('Larry', 'Ellison', 'Oracle'),
    ('Mark', 'Zuckerberg', 'Facebook'),
    ('Sergey', 'Brin', 'Google'),
    ('Larry', 'Page', 'Google'),
    ('Linux', 'Torvalds', 'Linux'),
]

for row in people:
    first_name, last_name, _ = row  ② ③
    print(first_name, last_name)
print()

for first_name, last_name, _ in people:  ④
    print(first_name, last_name)
print()

# extended unpacking
values = ['a', 'b', 'c', 'd', 'e', 'f']
x, y, *z = values
print(x, y, z)

x, *y, z = values
print(x, y, z)

*x, y, z = values
print(x, y, z)
```

① unpack values (which is an iterable) into individual variables

② unpack **row** into variables

③ _ is used as a "junk" variable that won't be used

④ a **for** loop unpacks if there is more than one variable

iterable_unpacking.py

```
a b c

Bill Gates
Steve Jobs
Paul Allen
Larry Ellison
Mark Zuckerberg
Sergey Brin
Larry Page
Linux Torvalds

Bill Gates
Steve Jobs
Paul Allen
Larry Ellison
Mark Zuckerberg
Sergey Brin
Larry Page
Linux Torvalds

a b ['c', 'd', 'e', 'f']
a ['b', 'c', 'd', 'e'] f
['a', 'b', 'c', 'd'] e f
```

Nested sequences

- Lists and tuples may contain other lists and tuples
- Use multiple brackets to specify higher dimensions
- Depth of nesting limited only by memory

Lists and tuples can contain any type of data, so a two-dimensional array can be created using a list of lists. A typical real-life scenario consists of reading data into a list of tuples.

There are many combinations – lists of tuples, lists of lists, etc.

To initialize a nested data structure, use nested brackets and parentheses, as needed.

Example

nested_sequences.py

```
#!/usr/bin/env python

people = [
    ('Melinda', 'Gates', 'Gates Foundation'),
    ('Steve', 'Jobs', 'Apple'),
    ('Larry', 'Wall', 'Perl'),
    ('Paul', 'Allen', 'Microsoft'),
    ('Larry', 'Ellison', 'Oracle'),
    ('Bill', 'Gates', 'Microsoft'),
    ('Mark', 'Zuckerberg', 'Facebook'),
    ('Sergey', 'Brin', 'Google'),
    ('Larry', 'Page', 'Google'),
    ('Linus', 'Torvalds', 'Linux'),
]

for person in people:  ①
    print(person[0], person[1])
print('-' * 60)

for person in people:
    first_name, last_name, product = person  ②
    print(first_name, last_name)
print('-' * 60)

for first_name, last_name, product in people:  ③
    print(first_name, last_name)
print('-' * 60)
```

① person is a tuple

② unpack person into variables

③ if there is more than one variable in a for loop, each element is unpacked

nested_sequences.py

```
Melinda Gates
Steve Jobs
Larry Wall
Paul Allen
Larry Ellison
Bill Gates
Mark Zuckerberg
Sergey Brin
Larry Page
Linus Torvalds
------------------------------------------------------------
Melinda Gates
Steve Jobs
Larry Wall
Paul Allen
Larry Ellison
Bill Gates
Mark Zuckerberg
Sergey Brin
Larry Page
Linus Torvalds
------------------------------------------------------------
Melinda Gates
Steve Jobs
Larry Wall
Paul Allen
Larry Ellison
Bill Gates
Mark Zuckerberg
Sergey Brin
Larry Page
Linus Torvalds
------------------------------------------------------------
```

Operators and keywords for sequences

- Operators + *
- Keywords **del in not in**

del deletes an entire string, list, or tuple. It can also delete one element, or a slice, from a list. del cannot remove elements of strings and tuples, because they are immutable.

in returns True if the specified object is an element of the sequence.

not in returns True if the specified object is *not* an element of the sequence.

+ adds one sequence to another

***** multiplies a sequence (i.e., makes a bigger sequence by repeating the original).

```
x in s  #note  x can be any Python object
s2 = s1 * 3
s3 = s1 + s2
```

Example

sequence_operators.py

```
#!/usr/bin/env python

colors = ["red", "blue", "green", "yellow", "brown", "black"]

months = (
    "Jan", "Feb", "Mar", "Apr", "May", "Jun",
    "Jul", "Aug", "Sep", "Oct", "Nov", "Dec",
)

print("yellow in colors: ", ("yellow" in colors))  ①
print("pink in colors: ", ("pink" in colors))

print("colors: ", ",".join(colors))  ②

del colors[4]  # remove brown   ③

print("removed 'brown':", ",".join(colors))

colors.remove('green')  ④

print("removed 'green':", ",".join(colors))

sum_of_lists = [True] + [True] + [False]  ⑤

print("sum of lists:", sum_of_lists)

product = [True] * 5  ⑥

print("product of lists:", product)
```

① Test for membership in list

② Concatenate iterable using ", " as delimiter

③ Permanently remove element with index 4

④ Remove element by value

⑤ Add 3 lists together; combines all elements

⑥ Multiply a list; replicates elements

sequence_operators.py

```
yellow in colors:  True
pink in colors:  False
colors:  red,blue,green,yellow,brown,black
removed 'brown': red,blue,green,yellow,black
removed 'green': red,blue,yellow,black
sum of lists: [True, True, False]
product of lists: [True, True, True, True, True]
```

Functions for all sequences

- Many builtin functions expect a sequence
- Syntax

```
n = len(s)
n = min(s)
n = max(s)
n = sum(s)
s2 = sorted(s)
s2 = reversed(s)
s = zip(s1,s2,...)
```

Many builtin functions accept a sequence as the parameter. These functions can be applied to a list, tuple, dictionary, or set.

len(s) returns the number of elements in s (the number of characters in a string).

min(s) and **max(s)** return the smallest and largest values in s. Types in s must be similar — mixing strings and numbers will raise an error.

sorted(s) returns a sorted list of any sequence s.

NOTE	min(), max(), and sorted() accept a named parameter **key**, which specifies a key function for converting each element of s to the value wanted for comparison. In other words, the key function could convert all strings to lower case, or provide one property of an object.

sum(s) returns the sum of all elements of s, which must all be numeric.

reversed(s) returns an iterator (not a list) that can loop through s in reverse order.

zip(s1,s2,...) returns an iterator consisting of (s1[0],s2[0]),(s1[1], s2[1]), ...). This can be used to "pivot" rows and columns of data.

Example

sequence_functions.py

```
#!/usr/bin/env python

colors = ["red", "blue", "green", "yellow", "brown", "black"]
months = (
    "Jan", "Feb", "Mar", "Apr", "May", "Jun",
    "Jul", "Aug", "Sep", "Oct", "Nov", "Dec",
)

print("colors: len is {}; min is {}; max is {}".format(len(colors), min(colors),
max(colors)))
print("months: len is {}; min is {}; max is {}".format(len(months), min(months),
max(months)))
print()

print("sorted:", end=' ')
for m in sorted(colors):   ①
    print(m, end=' ')
print()

phrase = ('dog', 'bites', 'man')
print(" ".join(reversed(phrase)))  ②
print()

first_names = "Bill Bill Dennis Steve Larry".split()
last_names = "Gates Joy Richie Jobs Ellison".split()

full_names = zip(first_names, last_names)  ③
print("full_names:", full_names)
print()

for first_name, last_name in full_names:
    print("{} {}".format(first_name, last_name))
```

① sorted() returns a sorted list

② reversed() returns a **reversed** iterator

③ zip() returns an iterator of tuples created from corresponding elements

sequence_functions.py

```
colors: len is 6; min is black; max is yellow
months: len is 12; min is Apr; max is Sep

sorted: black blue brown green red yellow
man bites dog

full_names: <zip object at 0x7f7fb01d24b0>

Bill Gates
Bill Joy
Dennis Richie
Steve Jobs
Larry Ellison
```

Using enumerate()

- Numbers items beginning with 0 (or specified value)
- Returns enumerate object that provides a *virtual* list of tuples

To get the index of each list item, use the builtin function enumerate(s). It returns an **enumerate object**.

```
for t in enumerate(s):
    print(t[0],t[1])

for i,item in enumerate(s):
    print(i,item)

for i,item in enumerate(s,1)
    print(i,item)
```

When you iterate through the following list with enumerate():

```
    [x,y,z]
```

you get this (virtual) list of tuples:

```
    [(0,x),(1,y),(2,z)]
```

You can give enumerate() a second argument, which is added to the index. This way you can start numbering at 1, or any other place.

Example

enumerate.py

```
#!/usr/bin/env python

colors = "red blue green yellow brown black".split()

months = "Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec".split()

for i, color in enumerate(colors):  ①
    print(i, color)

print()


for num, month in enumerate(months, 1):  ②
    print("{} {}".format(num, month))
```

① enumerate() returns iterable of (index, value) tuples

② Second parameter to enumerate is added to index

enumerate.py

```
0 red
1 blue
2 green
3 yellow
4 brown
5 black

1 Jan
2 Feb
3 Mar
4 Apr
5 May
6 Jun
7 Jul
8 Aug
9 Sep
10 Oct
11 Nov
12 Dec
```

The range() function

- Provides (virtual) list of numbers
- Slice-like parameters
- Syntax

```
range(stop)
range(start, stop)
range(start, stop, step)
```

The range() function returns a **range object**, that provides a list of numbers when iterated over. The parameters to range() are similar to the parameters for slicing (start, stop, step).

This can be useful to execute some code a fixed number of times.

Example

using_ranges.py

```
#!/usr/bin/env python

print("range(1, 6): ", end=' ')
for x in range(1, 6):  ①
    print(x, end=' ')
print()

print("range(6): ", end=' ')
for x in range(6):  ②
    print(x, end=' ')
print()

print("range(3, 12): ", end=' ')
for x in range(3, 12):  ③
    print(x, end=' ')
print()

print("range(5, 30, 5): ", end=' ')
for x in range(5, 30, 5):  ④
    print(x, end=' ')
print()

print("range(10, 0, -1): ", end=' ')
for x in range(10, 0, -1):  ⑤
    print(x, end=' ')
print()
```

① Start=1, Stop=6 (1 through 5)

② Start=0, Stop=6 (0 through 5)

③ Start=3, Stop=12 (3 through 11)

④ Start=5, Stop=30, Step=5 (5 through 25 by 5)

⑤ Start=10, Stop=1, Step=-1 (10 through 1 by 1)

using_ranges.py

```
range(1, 6):  1 2 3 4 5
range(6):  0 1 2 3 4 5
range(3, 12):  3 4 5 6 7 8 9 10 11
range(5, 30, 5):  5 10 15 20 25
range(10, 0, -1):  10 9 8 7 6 5 4 3 2 1
```

List comprehensions

- Shortcut for a for loop
- Optional if clause
- Always returns list
- Syntax

```
[ EXPR for VAR in SEQUENCE if EXPR ]
```

A list comprehension is a Python idiom that creates a shortcut for a for loop. A loop like this:

```
results = []
for var in sequence:
    results.append(expr)   # where expr involves var
```

can be rewritten as

```
results = [ expr for var in sequence ]
```

A conditional if may be added:

```
results = [ expr for var in sequence if expr ]
```

The loop expression can be a tuple. You can nest two or more for loops.

Example

list_comprehensions.py

```
#!/usr/bin/env python

fruits = ['watermelon', 'apple', 'mango', 'kiwi', 'apricot', 'lemon', 'guava']

ufruits = [fruit.upper() for fruit in fruits]        ①
afruits = [fruit.title() for fruit in fruits if fruit.startswith('a')]  ②

print("ufruits:", ufruits)
print("afruits:", afruits)
print()

values = [2, 42, 18, 39.7, 92, '14', "boom", ['a', 'b', 'c']]

doubles = [v * 2 for v in values]   ③

print("doubles:", doubles, '\n')

nums = [x for x in values if isinstance(x, int)]   ④
print(nums, '\n')

dirty_strings = ['    Gronk    ', 'PULABA       ', '        floog']

clean = [d.strip().lower() for d in dirty_strings]
for c in clean:
    print(">{}<".format(c), end=' ')
print("\n")

suits = 'Clubs', 'Diamonds', 'Hearts', 'Spades'
ranks = '2 3 4 5 6 7 8 9 10 J Q K A'.split()

deck = [(rank, suit) for suit in suits for rank in ranks]   ⑤

for rank, suit in deck:
    print("{}-{}".format(rank, suit))
```

① Simple transformation of all elements

② Transformation of selected elements only

③ Any kind of data is OK

④ Select only integers from list

⑤ More than one **for** is OK

list_comprehensions.py

```
ufruits: ['WATERMELON', 'APPLE', 'MANGO', 'KIWI', 'APRICOT', 'LEMON', 'GUAVA']
afruits: ['Apple', 'Apricot']

doubles: [4, 84, 36, 79.4, 184, '1414', 'boomboom', ['a', 'b', 'c', 'a', 'b', 'c']]

[2, 42, 18, 92]

>gronk< >pulaba< >floog<

2-Clubs
3-Clubs
4-Clubs
5-Clubs
6-Clubs
7-Clubs
8-Clubs
9-Clubs
10-Clubs
J-Clubs
Q-Clubs
K-Clubs
A-Clubs
2-Diamonds
3-Diamonds
4-Diamonds
5-Diamonds
6-Diamonds
7-Diamonds
8-Diamonds
9-Diamonds
```

etc etc

Generator Expressions

- Similar to list comprehensions
- Lazy evaluations – only execute as needed
- Syntax

```
( EXPR for VAR in SEQUENCE if EXPR )
```

A generator expression is very similar to a list comprehension. There are two major differences, one visible and one invisible.

The visible difference is that generator expressions are created with parentheses rather than square brackets. The invisible difference is that instead of returning a list, they return an iterable object.

The object only fetches each item as requested, and if you stop partway through the sequence; it never fetches the remaining items. Generator expressions are thus frugal with memory.

Example

generator_expressions.py

```
#!/usr/bin/env python

fruits = ['watermelon', 'apple', 'mango', 'kiwi', 'apricot', 'lemon', 'guava']

ufruits = (fruit.upper() for fruit in fruits)  ①
afruits = (fruit.title() for fruit in fruits if fruit.startswith('a'))

print("ufruits:", " ".join(ufruits))
print("afruits:", " ".join(afruits))
print()

values = [2, 42, 18, 92, "boom", ['a', 'b', 'c']]
doubles = (v * 2 for v in values)

print("doubles:", end=' ')
for d in doubles:
    print(d, end=' ')
print("\n")

nums = (int(s) for s in values if isinstance(s, int))
for n in nums:
    print(n, end=' ')
print("\n")

dirty_strings = ['   Gronk    ', 'PULABA       ', '        floog']

clean = (d.strip().lower() for d in dirty_strings)
for c in clean:
    print(">{}<".format(c), end=' ')
print("\n")

powers = ((i, i ** 2, i ** 3) for i in range(1, 11))
for num, square, cube in powers:
    print("{:2d} {:3d} {:4d}".format(num, square, cube))
print()
```

① These are all exactly like the list comprehension example, but return generators rather than lists

generator_expressions.py

```
ufruits: WATERMELON APPLE MANGO KIWI APRICOT LEMON GUAVA
afruits: Apple Apricot

doubles: 4 84 36 184 boomboom ['a', 'b', 'c', 'a', 'b', 'c']

2 42 18 92

>gronk< >pulaba< >floog<

 1   1    1
 2   4    8
 3   9   27
 4  16   64
 5  25  125
 6  36  216
 7  49  343
 8  64  512
 9  81  729
10 100 1000
```

Chapter 4 Exercises

Exercise 4-1 (pow2.py)

Print out all the powers of 2 from 2^0 through 2^{31}.

Use the ** operator, which raises a number to a power.

> **NOTE** For exercises 4-2 and 4-3, start with the file sequences.py, which has the lists ctemps and fruits already typed in. You can put all the answers in sequences.py

Exercise 4-2 (sequences.py)

ctemps is a list of Celsius temperatures. Loop through ctemps, convert each temperature to Fahrenheit, and print out both temperatures.

Exercise 4-3 (sequences.py)

Use a list comprehension to copy the list **fruits** to a new list named **clean_fruits**, with all fruits in lower case and leading/trailing white space removed. Print out the new list.

HINT: Use chained methods (x.spam().ham())

Exercise 4-4 (sieve.py)

FOR ADVANCED STUDENTS

The "Sieve of Eratosthenes" is an ancient algorithm for finding prime numbers. It works by starting at 2 and checking each number up to a specified limit. If the number has been marked as non-prime, it is skipped. Otherwise, it is prime, so it is output, and all its multiples are marked as non-prime.

Write a program to implement this algorithm. Specify the limit (the highest number to check) on the script's command line. Supply a default if no limit is specified.

Initialize a list (maybe named **is_prime**) to the size of the limit plus one (use * to multiply a single-item list). All elements should be set to **True**.

Use two *nested* loops.

The outer loop will check each value (element of the array) from 2 to the upper limit. (use the `range()`) function.

If the element has a **True** value (is prime), print out its value. Then, execute a second loop iterates through all the multiples of the number, and marks them as **False** (i.e., non-prime).

No action is needed if the value is False. This will skip the non-prime numbers.

TIP	Use range() to generate the multiples of the current number.

NOTE	In this exercise, the *value* of the element is either **True** or **False** — the *index* is the number be checked for primeness.

See next page for the pseudocode for this program:

Pseudocode for sieve.py

```
if # command line args == 1
    get LIMIT from command line
else
    set LIMIT to 50

Initialize IS_PRIMES list to size LIMIT+1, with all TRUE values

for NUM  from 2 to LIMIT+1
    if IS_PRIME[NUM]
        output NUM
        for M from NUM to LIMIT+1, counting by NUM
            IS_PRIME[M] = FALSE
```

Chapter 5: Working with Files

Objectives

- Reading a text file line-by-line
- Reading an entire text files
- Reading all lines of a text file into an array
- Writing to a text file

Text file I/O

- Create a file object with open
- Specify modes: read/write, text/binary
- Read or write from file object
- Close file object (or use **with** block)

Python provides a file object that is created by the built-in open() function. From this file object you can read or write data in several different ways. When opening a file, you specify the file name and the mode, which says whether you want to read, write, or append to the file, and whether you want text or binary (raw) processing.

NOTE	This chapter is about working with generic files. For files in standard formats, such as XML, CSV, YAML, JSON, and many others, Python has format-specific modules to read them.

Opening a text file

- Specify the file name and the mode
- Returns a file object
- Mode can be read or write
- Specify "b" for binary (raw) mode
- Omit mode for reading

Open a text file with the open() command. Arguments are the file name, which may be specified as a relative or absolute path, and the mode. The mode consists of "r" for read, "w" for write, or "a" for append. To open a file in binary mode, add "b" to the mode, as in "rb", "wb", or "ab".

If you omit the mode, "r" is the default.

Example

```
ty = open("tyger.txt","r")  open for reading in text mode
ty = open("tyger.txt")      open for reading in text mode (default mode)
junk = open("junk.dat","rb")    open for reading in raw mode
stf = open("stuff.txt","w") open for writing in text mode
stf = open("stuff.txt","x") open for writing in text mode, fail if file exists
moju = open("morejunk.dat","wb")    open for writing in raw mode
config = open("spam.cfg","a")   open for append in text mode
```

TIP The **fileinput** module in the standard library makes it easy to loop over each line in all files specified on the command line, or STDIN if no files are specified. This avoids having to open and close each file.

The *with* block

- Provides "execution context"
- Automagically closes file object
- Not specific to file objects

Because it is easy to forget to close a file object, you can use a **with** block to open your file. This will automatically close the file object when the block is finished. The syntax is

```
with open(filename, mode) as fileobject:
    # process fileobject
```

Reading a text file

- Iterate through file with for/in

```
    for line in file_in
```

- Use methods of the file object

```
    file_in.readlines()   read all lines from file_in
    file_in.read()        read all of file_in
    file_in.read(n)       read n characters from file in text mode; n bytes from
file_in in binary mode
    file_in.readline()    read next line from file_in
```

The easiest way to read a file is by looping through the file object with a for/in loop. This is possible because the file object is an iterator, which means the object knows how to provide a sequence of values.

You can also read a text file one line or multiple lines at a time. **readline()** reads the next available line; **readlines()** reads all lines into a list.

read() will read the entire file; **read(n)** will read n bytes from the file (n *characters* if in text mode).

readline() will read the next line from the file.

Example

read_tyger.py

```
#!/usr/bin/env python

with open("../DATA/tyger.txt", "r") as tyger_in:  ①
    for line in tyger_in:  ②
        print(line, end='')  ③
```

① **tyger_in** is return value of **open(...)**

② **tyger_in** is a *generator*, returning one line at a time

③ the line already has a newline, so **print()** does not need one

read_tyger.py

```
           The Tyger

Tyger! Tyger! burning bright
In the forests of the night,
What immortal hand or eye
Could frame thy fearful symmetry?

In what distant deeps or skies
Burnt the fire of thine eyes?
On what wings dare he aspire?
What the hand dare seize the fire?

And what shoulder, & what art,
Could twist the sinews of thy heart?
And when thy heart began to beat,
What dread hand? & what dread feet?

What the hammer? what the chain?
In what furnace was thy brain?
What the anvil? what dread grasp
Dare its deadly terrors clasp?

When the stars threw down their spears
And water'd heaven with their tears,
Did he smile his work to see?
Did he who made the Lamb make thee?

Tyger! Tyger! burning bright
In the forests of the night,
What immortal hand or eye
Dare frame thy fearful symmetry?

                    by William Blake
```

Example

reading_files.py

```
#!/usr/bin/env python

FILE_NAME = '../DATA/mary.txt'

mary_in = open(FILE_NAME)  ①
# read file...
mary_in.close()  ②

with open(FILE_NAME) as mary_in:  ③
    for raw_line in mary_in:  ④
        line = raw_line.rstrip()  ⑤
        print(line)
print('-' * 60)

with open(FILE_NAME) as mary_in:
    contents = mary_in.read()  ⑥
    print("NORMAL:")
    print(contents)
    print("=" * 20)
    print("RAW:")
    print(repr(contents))  ⑦
print('-' * 60)

with open(FILE_NAME) as mary_in:
    lines_with_nl = mary_in.readlines()  ⑧
    print(lines_with_nl)
print('-' * 60)

with open(FILE_NAME) as mary_in:
    lines_without_nl = mary_in.read().splitlines()  ⑨
    print(lines_without_nl)
```

① open file for reading

② close file (easy to forget to do this!)

③ open file for reading

④ iterate over lines in file (line retains \n)

⑤ rstrip('\n\r') removes whitespace (including \r or \n) from end of string

⑥ read entire file into one string

⑦ print string in "raw" mode

⑧ readlines() reads all lines into an array

⑨ splitlines() splits string on '\n' into lines

reading_files.py

```
Mary had a little lamb,
Its fleece was white as snow,
And everywhere that Mary went
The lamb was sure to go
------------------------------------------------------------
NORMAL:
Mary had a little lamb,
Its fleece was white as snow,
And everywhere that Mary went
The lamb was sure to go

====================
RAW:
'Mary had a little lamb,\nIts fleece was white as snow,\nAnd everywhere that Mary
went\nThe lamb was sure to go\n'
------------------------------------------------------------
['Mary had a little lamb,\n', 'Its fleece was white as snow,\n', 'And everywhere that
Mary went\n', 'The lamb was sure to go\n']
------------------------------------------------------------
['Mary had a little lamb,', 'Its fleece was white as snow,', 'And everywhere that Mary
went', 'The lamb was sure to go']
```

Writing to a text file

- Use write() or writelines()
- Add \n manually

To write to a text file, use the write() function to write a single string; or writelines() to write a list of strings.

writelines() will not add newline characters, so make sure the items in your list already have them.

Example

write_file.py

```
#!/usr/bin/env python

states = (
    'Virginia',
    'North Carolina',
    'Washington',
    'New York',
    'Florida',
    'Ohio',
)

with open("states.txt", "w") as states_out: ①
    for state in states:
        states_out.write(state + "\n")  ②
```

① "w" opens for writing, "a" for append

② write() does not add \n automatically

write_file.py

cat states.txt (Windows: type states.txt)

```
Virginia
North Carolina
Washington
New York
Florida
Ohio
```

"writelines" should have been called "writestrings"

Table 9. File Methods

Function	Description
f.close()	close file f
f.flush()	write out buffered data to file f
s = f.read(n) s = f.read()	read size bytes from file f into string s; if n is ⇐ 0, or omitted, reads entire file
s = f.readline() s = f.readline(n)	read one line from file f into string s. If n is specified, read no more than n characters
m = f.readlines()	read all lines from file f into list m
f.seek(n) f.seek(n,w)	position file f at offset n for next read or write; if argument w (whence) is omitted or 0, offset is from beginning; if 1, from current file position, if 2, from end of file
f.tell()	return current offset from beginning of file
f.write(s)	write string s to file f
f.writelines(m)	write list of strings m to file f; does not add line terminators

Chapter 5 Exercises

Exercise 5-1 (line_no.py)

Write a program to display each line of a file preceded by the line number. Allow your program to process one or more files specified on the command line. Be sure to reset the line number for each file.

> **TIP** Use enumerate().

Test with the following commands:

```
python line_no.py DATA/tyger.txt
python line_no.py DATA/parrot.txt DATA/tyger.txt
```

Test with other files, as desired

Exercise 5-2 (alt_lines.py)

Write a program to create two files, a.txt and b.txt from the file alt.txt. Lines that start with 'a' go in a.txt; the other lines (which all start with 'b') go in b.txt. Compare the original to the two new files.

Exercise 5-3 (count_alice.py, count_words.py)

A. Write a program to count how many lines of alice.txt contain the word "Alice". (There should be 392).

> **TIP** Use the **in** operator to test whether a line contains the word "Alice"

B. Modify count_alice.py to take the first command line parameter as a word to find, and the remaining parameters as filenames. For each file, print out the file name and the number of lines that contain the specified word. Test thoroughly

FOR ADVANCED STUDENTS (icount_words.py) Modify count_words.py to make the search case-insensitive.

Chapter 6: Dictionaries and Sets

Objectives

- Creating dictionaries
- Using dictionaries for mapping and counting
- Iterating through key-value pairs
- Reading a file into a dictionary
- Counting with a dictionary
- Using sets

About dictionaries

- A collection
- Associates keys with values
- called "hashes", "hash tables" or "associative arrays" in other languages
- Rich set of functions available

A dictionary is a collection that contains key-value pairs. Dictionaries are not sequential like lists, tuples, and strings; they function more as a lookup table. They map one value to another.

The keys must be immutable – lists and dictionaries may not be used as keys. Any immutable type may be a key, although typically keys are strings.

Prior to version 3.6, the elements of a dictionary are in no particular order. Starting with 3.6, elements are stored in the order added. If you iterate over *dictionary*.items(), it will iterate in the order that the elements were added.

Values can be any Python object – strings, numbers, tuples, lists, dates, or anything else.

For instance, a dictionary might

- map column names in a database table to their corresponding values
- map almost any group of related items to a unique identifier
- map screen names to real names
- map zip codes to a count of customers per zip code
- count error codes in a log file
- count image tags in an HTML file

When to use dictionaries?

- Mapping
- Counting

Dictionaries are very useful for mapping a set of keys to a corresponding set of values. You could have a dictionary where the key is a candidate for office, and value is the state in which the candidate is running, or the value could be an object containing many pieces of information about the candidate.

Dictionaries are also handy for counting. The keys could be candidates and the values could be the number of votes each candidate received.

Creating dictionaries

- Create dictionaries with { } or dict()
- Create from (nearly) any sequence
- Add additional keys by assignment

To create a dictionary, use the dict() function or {}. The dictionary can be created empty, or you can initialize it with one or more key/value pairs, separated by colons.

To add more keys, assign to the dictionary using square brackets.

Remember, braces are only used to create a dictionary; indexing uses brackets like all the other container types. To get the value for a given key, specify the key with square brackets or use the get() method.

Example

creating_dicts.py

```
#!/usr/bin/env python

d1 = dict()  ①

airports = {'IAD': 'Dulles', 'SEA': 'Seattle-Tacoma',  ②
            'RDU': 'Raleigh-Durham', 'LAX': 'Los Angeles'}

d2 = {}
d3 = dict(red=5, blue=10, yellow=1, brown=5, black=12)  ③

pairs = [('Washington', 'Olympia'), ('Virginia', 'Richmond'),
         ('Oregon', 'Salem'), ('California', 'Sacramento')]

state_caps = dict(pairs)  ④

print(d3['red'])  ⑤
print(airports['LAX'])

airports['SLC'] = 'Salt Lake City'  ⑥
airports['LAX'] = 'Lost Angels'  ⑦
print(airports['SLC'])
```

① create new empty dict

② initialize dict with literal key/value pairs (keys can be any string, number or tuple)

③ initialize dict with named parameters; keys must be valid identifier names

④ initialize dict with an iterable of pairs

⑤ print value for given key

⑥ assign to new key

⑦ overwrite existing key

creating_dicts.py

```
5
Los Angeles
Salt Lake City
```

Table 10. Frequently used dictionary functions and operators

Function	Description
len(D)	the number of elements in D
D[k]	the element of D with key k
D[k] = v	set D[k] to v
del D[k]	remove element from D whose key is k
D.clear()	remove all items from a dictionary
k in D	True if key k exists in D
k not in D	True if key k does not exist in D
D.get(k[, x])	D[k] if k in a, else x
D.items()	return an iterator over (key, value) pairs
D.update([b])	updates (and overwrites) key/value pairs from b
D.setdefault(k[, x])	a[k] if k in D, else x (also setting it)

Table 11. Less frequently used dictionary functions

Function	Description
D.keys()	return an iterator over the mapping's keys
D.values()	return an iterator over the mapping's values
D.copy()	a (shallow) copy of D
D.has_key(k)	True if a has D key k, else False (but use in)
D.fromkeys(seq[, value])	Creates a new dictionary with keys from seq and values set to value
D.pop(k[, x])	a[k] if k in D, else x (and remove k)
D.popitem()	remove and return an arbitrary (key, value) pair

Getting dictionary values

- d[key]
- d.get(key,default-value)
- d.setdefault(key, default-value)

There are three main ways to get the value of a dictionary element, given the key.

Using the key as an index retrieves the corresponding value, or raises a KeyError.

The get() method returns the value, or a default value if the key does not exist. If no default value is specified, and the key does not exist, get() returns None.

The setdefault() method is like get(), but if the key does not exist, adds the key and the default value to the dictionary.

Use the **in** operator to test whether a dictionary contains a given key.

Example

getting_dict_values.py

```
#!/usr/bin/env python

d1 = dict()

airports = {'IAD': 'Dulles', 'SEA': 'Seattle-Tacoma',
            'RDU': 'Raleigh-Durham', 'LAX': 'Los Angeles'}

d2 = {}
d3 = dict(red=5, blue=10, yellow=1, brown=5, black=12)

pairs = [('Washington', 'Olympia'), ('Virginia', 'Richmond'),
         ('Oregon', 'Salem'), ('California', 'Sacramento')]

state_caps = dict(pairs)

print(d3['red'])
print(airports['LAX'])

airports['SLC'] = 'Salt Lake City'
airports['LAX'] = 'Lost Angels'
print(airports['SLC'])  ①

key = 'PSP'
if key in airports:
    print(airports[key])  ②

print(airports.get(key))  ③
print(airports.get(key, 'NO SUCH AIRPORT'))  ④

print(airports.setdefault(key, 'Palm Springs'))  ⑤
print(key in airports)  ⑥
```

① print value where key is 'SLC'

② print key if key is in dictionary

③ get value if key in dict, otherwise get None

④ get value if key in dict, otherwise get 'NO SUCH AIRPORT'

⑤ get value if key in dict, otherwise get 'Palm Springs' AND set key

⑥ check for key in dict

getting_dict_values.py

```
5
Los Angeles
Salt Lake City
None
NO SUCH AIRPORT
Palm Springs
True
```

Iterating through a dictionary

- d.items() generates key/value tuples
- Key order
  - before 3.6: not predictable
  - 3.6 and later: insertion order

To iterate through tuples containing the key and the value, use the method DICT.items(). It generates tuples in the form (KEY,VALUE).

Before 3.6, elements are retrieved in arbitrary order; beginning with 3.6, elements are retrieved in the order they were added.

To do something with the elements in a particular order, the usual approach is to pass ***DICT*.items()** to the **sorted()** function and loop over the result.

TIP If you iterate through the dictionary itself (as opposed to *dictionary*.items()), you get just the keys.

Example

iterating_over_dicts.py

```
#!/usr/bin/env python

airports = {'IAD': 'Dulles', 'SEA': 'Seattle-Tacoma',
            'RDU': 'Raleigh-Durham', 'LAX': 'Los Angeles'}

for abbr, airport in airports.items():  ①
    print(abbr, airport)
```

① items() returns a virtual list of key:value pairs

iterating_over_dicts.py

```
IAD Dulles
SEA Seattle-Tacoma
RDU Raleigh-Durham
LAX Los Angeles
```

Reading file data into a dictionary

- Data must have unique key
- Key is one column, value can be string, number, list, or tuple (or anything else!)

To read a file into a dictionary, read the file one line at a time, splitting the line into fields as necessary. Use a unique field for the key. The value can be either some other field, or a group of fields, as stored in a list or tuple. Remember that the value can be any Python object.

Example

read_into_dict_of_tuples.py

```
#!/usr/bin/env python

from pprint import pprint

knight_info = {}  ①

with open("../DATA/knights.txt") as knights_in:
    for line in knights_in:
        name, title, color, quest, comment = line.rstrip('\n\r').split(":")
        knight_info[name] = title, color, quest, comment  ②

pprint(knight_info)
print()

for name, info in knight_info.items():
    print(info[0], name)

print()
print(knight_info['Robin'][2])
```

① create empty dict

② create new dict element with **name** as key and a tuple of the other fields as the value

read_into_dict_of_tuples.py

```
{'Arthur': ('King', 'blue', 'The Grail', 'King of the Britons'),
 'Bedevere': ('Sir', 'red, no blue!', 'The Grail', 'AARRRRRRRGGGGHH'),
 'Galahad': ('Sir', 'red', 'The Grail', "'I could handle some more peril'"),
 'Gawain': ('Sir', 'blue', 'The Grail', 'none'),
 'Lancelot': ('Sir', 'blue', 'The Grail', '"It\'s too perilous!"'),
 'Robin': ('Sir', 'yellow', 'Not Sure', 'He boldly ran away')}

King Arthur
Sir Galahad
Sir Lancelot
Sir Robin
Sir Bedevere
Sir Gawain

Not Sure
```

TIP See also **read_into_dict_of_dicts.py** and **read_into_dict_of_named_tuples.py** in the EXAMPLES folder.

Counting with dictionaries

- Use dictionary where key is item to be counted
- Value is number of times item has been seen.

To count items, use a dictionary where the key is the item to be counted, and the value is the number of times it has been seen (i.e., the count).

The get() method is useful for this. The first time an item is seen, get can return 0; thereafter, it returns the current count. Each time, add 1 to this value.

TIP Check out the **Counter** class in the **collections** module

Example

count_with_dict.py

```
#!/usr/bin/env python

counts = {}  ①
with open("../DATA/breakfast.txt") as breakfast_in:
    for line in breakfast_in:
        breakfast_item = line.rstrip('\n\r')
        if breakfast_item in counts:   ②
            counts[breakfast_item] = counts[breakfast_item] + 1   ③
        else:
            counts[breakfast_item] = 1 ④

for item, count in counts.items():
    print(item, count)
```

① create empty dict

② create new dict element with **name** as key and a tuple of the other fields as the value

count_with_dict.py

```
spam 10
eggs 3
crumpets 1
```

As a short cut, you could check for the key and increment with a one-liner:

```
counts[breakfast_item] = counts.get(breakfast_item,0) + 1
```

About sets

- Find unique values
- Check for membership
- Find union or intersection
- Like a dictionary where all values are True
- Two kinds of sets
  - set (mutable)
  - frozenset (immutable)

A set is useful when you just want to keep track of a group of values, but there is no particular value associated with them .

The easy way to think of a set is that it's like a dictionary where the value of every element is True. That is, the important thing is whether the key is in the set or not.

There are methods to compute the union, intersection, and difference of sets, along with some more esoteric functionality.

As with dictionary keys, the values in a set must be unique. If you add a key that already exists, it doesn't change the set.

You could use a set to keep track of all the different error codes in a file, for instance.

Creating Sets

- Literal set: {item1, item2, ...}
- Use set() or frozenset()
- Add members with SET.add()

To create a set, use the set() constructor, which can be initialized with any iterable. It returns a set object, to which you can then add elements with the add() method.

Create a literal set with curly braces containing a comma-separated list of the members. This won't be confused with a literal dictionary, because dictionary elements contain a colon separating the key and value.

To create an immutable set, use frozenset(). Once created, you my not add or delete items from a frozenset. This is useful for quick lookup of valid values.

Working with sets

- Common set operations
  - adding an element
  - deleting an element
  - checking for membership
  - computing
    - union
    - intersection
    - symmetric difference (xor)

The most common thing to do with a set is to check for membership. This is accomplished with the **in** operator. New elements are added with the **add()** method, and elements are deleted with the **del** operator.

Intersection (**&**) of two sets returns a new set with members common to both sets.

Union (|) of two sets returns a new set with all members from both sets.

Xor (^) of two sets returns a new set with members that are one one set or the other, but not both. (AKA symmetric difference)

Difference (**-**) of two sets returns a new set with members on the right removed from the set on the left.

Example

set_examples.py

```
#!/usr/bin/env python

set1 = {'red', 'blue', 'green', 'purple', 'green'}  ①
set2 = {'green', 'blue', 'yellow', 'orange'}

set1.add('taupe')  ②

print(set1)
print(set2)
print(set1 & set2)  ③
print(set1 | set2)  ④
print(set1 ^ set2)  ⑤
print(set1 - set2)  ⑥
print(set2 - set1)
print()

food = 'spam ham ham spam spam spam ham spam spam eggs cheese spam'.split()
food_set = set(food)  ⑦
print(food_set)
```

① create literal set

② add element to set (ignored if already in set)

③ intersection of two sets

④ union of two sets

⑤ XOR (symmetric difference); items in one set but not both

⑥ Remove items in right set from left set

⑦ Create set from iterable (e.g., list)

set_examples.py

```
{'blue', 'green', 'red', 'purple', 'taupe'}
{'orange', 'blue', 'yellow', 'green'}
{'blue', 'green'}
{'blue', 'orange', 'yellow', 'green', 'red', 'purple', 'taupe'}
{'red', 'purple', 'taupe', 'orange', 'yellow'}
{'taupe', 'red', 'purple'}
{'orange', 'yellow'}

{'spam', 'cheese', 'ham', 'eggs'}
```

Table 12. Set functions and methods

Function	Description
m in S	True if s contains member m
m not in S	True if S does not contain member m
len(s)	the number of items in S
S.add(m)	Add member m to S (if S already contains m do nothing)
S.clear()	remove all members from S
S.copy()	a (shallow) copy of S
S - S2 S.difference(S2)	Return the set of all elements in S that are not in S2
S.difference_update(S2)	Remove all members of S2 from S
S.discard(m)	Remove member m from S if it is a member. If m is not a member, do nothing.
S & S2 S.intersection(S2)	Return new set with all unique members of S and S2
S.isdisjoint(S2)	Return True if S and S2 have no members in common
S.issubset(S2)	Return True is S is a subset of S2
S.issuperset(S2)	Return True is S2 is a subset of S
S.pop()	Remove and return an arbitrary set element. Raises KeyError if the set is empty.
S.remove(m)	Remove member m from a set; it must be a member.
S ^ S2 S.symmetric_difference(S2)	Return all members in S or S2 but not both.
S.symmetric_difference_update(S2)	Update a set with the symmetric difference of itself and another.
S | S2 S.union(S2)	Return all members that are in S or S2
S.update(S2)	Update a set with the union of itself and S2

Chapter 6 Exercises

Exercise 6-1 (scores.py)

A class of students has taken a test. Their scores have been stored in **testscores.dat**. Write a program named **scores.py** to read in the data (read it into a dictionary where the keys are the student names and the values are the test scores). Print out the student names, one per line, sorted, and with the numeric score and letter grade. After printing all the scores, print the average score.

```
Grading Scale
95-100
A
89-94
B
83-88
C
75-82
D
< 75
F
```

Exercise 6-2 (shell_users.py)

Using the file named **passwd**, write a program to count the number of users using each shell. To do this, read **passwd** one line at a time. Split each line into its seven (colon-delimited) fields. The shell is the last field. For each entry, add one to the dictionary element whose key is the shell.

When finished reading the password file, loop through the keys of the dictionary, printing out the shell and the count.

Exercise 6-3 (common_fruit.py)

Using sets, compute which fruits are in both **fruit1.txt** and **fruit2.txt**. To do this, read the files into sets (the files contain one fruit per line) and find the intersection of the sets.

> What if fruits are in both files, but one is capitalized and the other isn't?

Exercise 6-4 (set_sieve.py)

FOR ADVANCED STUDENTS Rewrite **sieve.py** to use a set rather than a list to keep track of which numbers are non-prime. This turns out to be easier – you don't have to initialize the set, as you did with the list.

Chapter 7: Functions

Objectives

- Creating functions
- Returning values from functions
- Passing required and optional positional parameters
- Passing required and optional named (keyword) parameters
- Understanding variable scope

Defining a function

- Indent body
- Specify parameters
- Variables are local by default

Functions are one of Python's callable types. Once a function is defined, it can be called from anywhere.

Functions can take fixed or variable parameters and return single or multiple values.

Functions must be defined before they can be called.

Define a function with the **def** keyword, the name of the function, a (possibly empty) list of parameters in parentheses, and a colon.

Example

function_basics.py

```
#!/usr/bin/env python


def say_hello():  ①
    print("Hello, world")
    print()
    ②


say_hello()  ③


def get_hello():
    return "Hello, world"  ④


h = get_hello()  ⑤
print(h)
print()


def sqrt(num):  ⑥
    return num ** .5


m = sqrt(1234)  ⑦
n = sqrt(2)

print("m is {:.3f} n is {:.3f}".format(m, n))
```

① Function takes no parameters

② If no **return** statement, return None

③ Call function (arguments, if any, in ())

④ Function returns value

⑤ Store return value in h

⑥ Function takes exactly one argument

⑦ Call function with one argument

function_basics.py

```
Hello, world

Hello, world

m is 35.128 n is 1.414
```

Returning values

- Use the **return** statement
- Return any Python object

To return a value from a function, use the return statement. It can return any Python object, including scalar values, lists, tuple, and dictionaries.

return without a value returns None.

Example

```
return ①
return 5 ②
return x ③
return name,quest,color ④
```

① return None

② return integer 5

③ return object x

④ return tuple of values

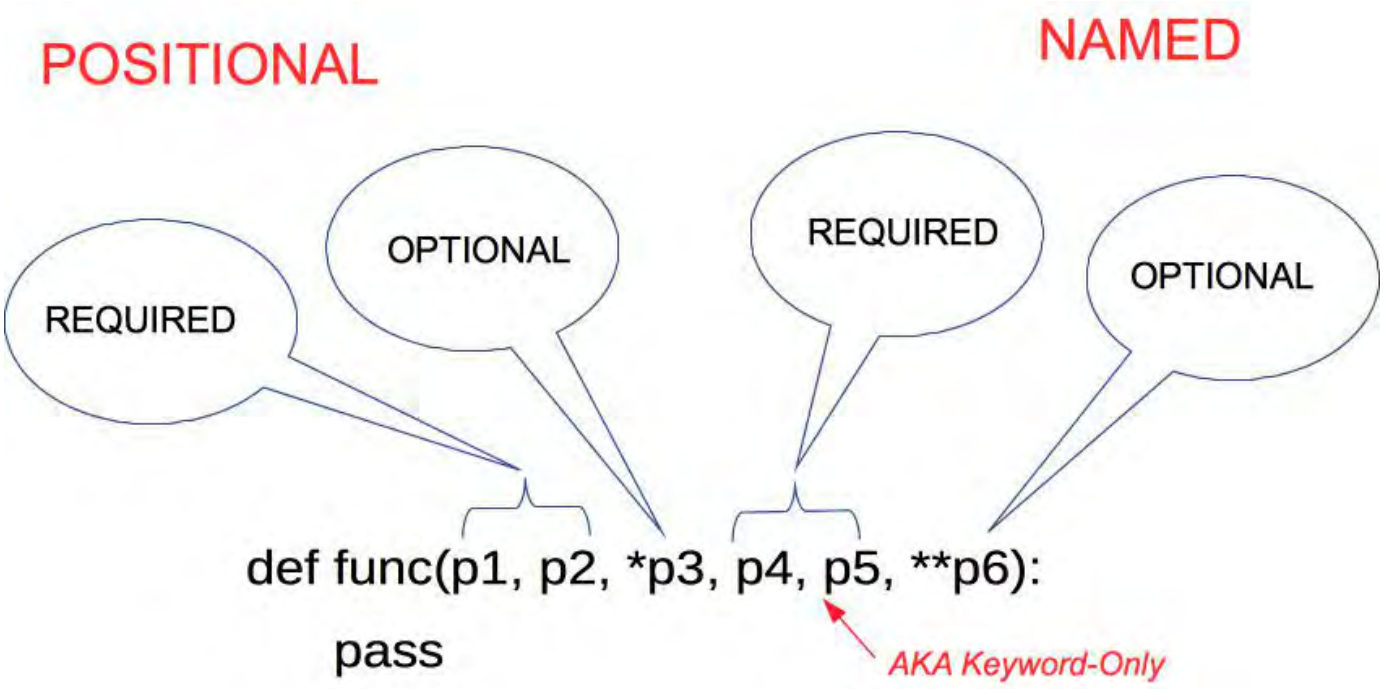
> **TIP** Remember that **return** is a statement, not a function.

Function parameters

- Four kinds of parameters
  - Required positional
  - Optional positional
  - Required named (AKA keyword-only)
  - Optional named
- No type checking

When defining a function, you need to specify the parameters that the function expects. There are four ways to do this, as described below. Parameters must be specified in the below order (i.e., fixed, optional, keyword-only, keyword).

Required parameters may have default values.



Positional parameters

Required positional parameters

Specify one or more positional parameters. The interpreter will then expect exactly that many parameters. Positional parameters are available via their names.

```
def spam(a,b,c):
    # function body
```

This function expects three parameters, which can be of any Python data type.

Positional parameters can have default values, in which case the parameters can be omitted when the function is called.

Optional positional parameters

Prefix a parameter with one asterisk to accept any number of positional parameters. The parameter name will be a tuple of all the values.

```
def eggs(*params):
    # function body
```

This function will take any number of arguments, which are then available in the tuple **params**.

Named parameters

Keyword-only parameters (required named parameters)

Keyword-only parameters are required parameters with specific names that come after optional parameters, but before optional named parameters. Keyword-only parameters are available in the function via their names. This is in comparison to normal keyword parameters, which are all grouped into a dictionary.

If the function doesn't require optional parameters, use a single '*' character as a placeholder after any fixed parameters.

```
def spam(*, ham=True, eggs=5):
    # function body
```

The **pandas** read_csv() method is a great example of a function where named parameters are a good fit. There are over twenty possible parameters, and it would be difficult for users to provide all of them with every call, so it has named parameters, which all have reasonable defaults. The only required parameter is the name of the file to read.

```
pandas.read_csv = read_csv(filepath_or_buffer, sep=',', delimiter=None, header='infer',
names=None, index_col=None, usecols=None, squeeze=False, prefix=None,
mangle_dupe_cols=True, dtype=None, engine=None, converters=None, true_values=None,
false_values=None, skipinitialspace=False, skiprows=None, nrows=None, na_values=None,
keep_default_na=True, na_filter=True, verbose=False, skip_blank_lines=True,
parse_dates=False, infer_datetime_format=False, keep_date_col=False, date_parser=None,
dayfirst=False, iterator=False, chunksize=None, compression='infer', thousands=None,
decimal=b'.', lineterminator=None, quotechar='"', quoting=0, escapechar=None,
comment=None, encoding=None, dialect=None, tupleize_cols=False, error_bad_lines=True,
warn_bad_lines=True, skipfooter=0, skip_footer=0, doublequote=True,
delim_whitespace=False, as_recarray=False, compact_ints=False, use_unsigned=False,
low_memory=True, buffer_lines=None, memory_map=False, float_precision=None)
```

Keyword parameters (optional named parameters)

Specify optional named parameters. Prefix the parameter with two asterisks. The parameter is a dictionary of the names and values passed in as "name=value" pairs.

```
def spam(**kw):
    # function body
```

This function takes any number of keyword arguments, which are available in the dictionary kw:

```
spam(name="bob",grade=10)
```

Example

function_parameters.py

```
#!/usr/bin/env python

def fun_one():  ①
    print("Hello, world")


print("fun_one():", end=' ')
fun_one()
print()


def fun_two(n):  ②
    return n ** 2


x = fun_two(5)
print("fun_two(5) is {}\n".format(x))


def fun_three(count=3):  ③
    for _ in range(count):
        print("spam", end=' ')
    print()


fun_three()
fun_three(10)
print()


def fun_four(n, *opt):  ④
    print("fun_four():")
    print("n is ", n)
    print("opt is", opt)
    print('-' * 20)


fun_four('apple')
fun_four('apple', "blueberry", "peach", "cherry")


def fun_five(*, spam=0, eggs=0):  ⑤
    print("fun_five():")
```

```
    print("spam is:", spam)
    print("eggs is:", eggs)
    print()


fun_five(spam=1, eggs=2)
fun_five(eggs=2, spam=2)
fun_five(spam=1)
fun_five(eggs=2)
fun_five()


def fun_six(**named_args):  ⑥
    print("fun_six():")
    for name in named_args:
        print(name, "==> ", named_args[name])


fun_six(name="Lancelot", quest="Grail", color="red")
```

① no parameters

② one required parameter

③ one required parameter with default value

④ one fixed, plus optional parameters

⑤ keyword-only parameters

⑥ keyword (named) parameters

function_parameters.py

```
fun_one(): Hello, world

fun_two(5) is 25

spam spam spam
spam spam spam spam spam spam spam spam spam spam

fun_four():
n is  apple
opt is ()
--------------------
fun_four():
n is  apple
opt is ('blueberry', 'peach', 'cherry')
--------------------
fun_five():
spam is: 1
eggs is: 2

fun_five():
spam is: 2
eggs is: 2

fun_five():
spam is: 1
eggs is: 0

fun_five():
spam is: 0
eggs is: 2

fun_five():
spam is: 0
eggs is: 0

fun_six():
name ==>  Lancelot
quest ==>  Grail
color ==>  red
```

Variable scope

- Assignment inside function creates local variables
- Parameters are local variables
- All other variables are global

When you assign to a variable in a function, that variable is local – it is only visible within the function. If you use an existing variable that has not been assigned to in the function, then it will use the global variable.

Too many globals can make a program hard to read and debug.

Example

variable_scope.py

```
#!/usr/bin/env python

x = 5


def spam():
    x = 22  ①
    print("spam(): x is", x)
    y = "wolverine"  ②
    print("spam(): y is", y)


def eggs():
    print("eggs(): x is", x)  ③
    y = "wolverine"
    print("eggs(): y is", y)


spam()
print()
eggs()
print()
print("main: x is ", x)
```

① Local variable; does not modify global x

② Local variable

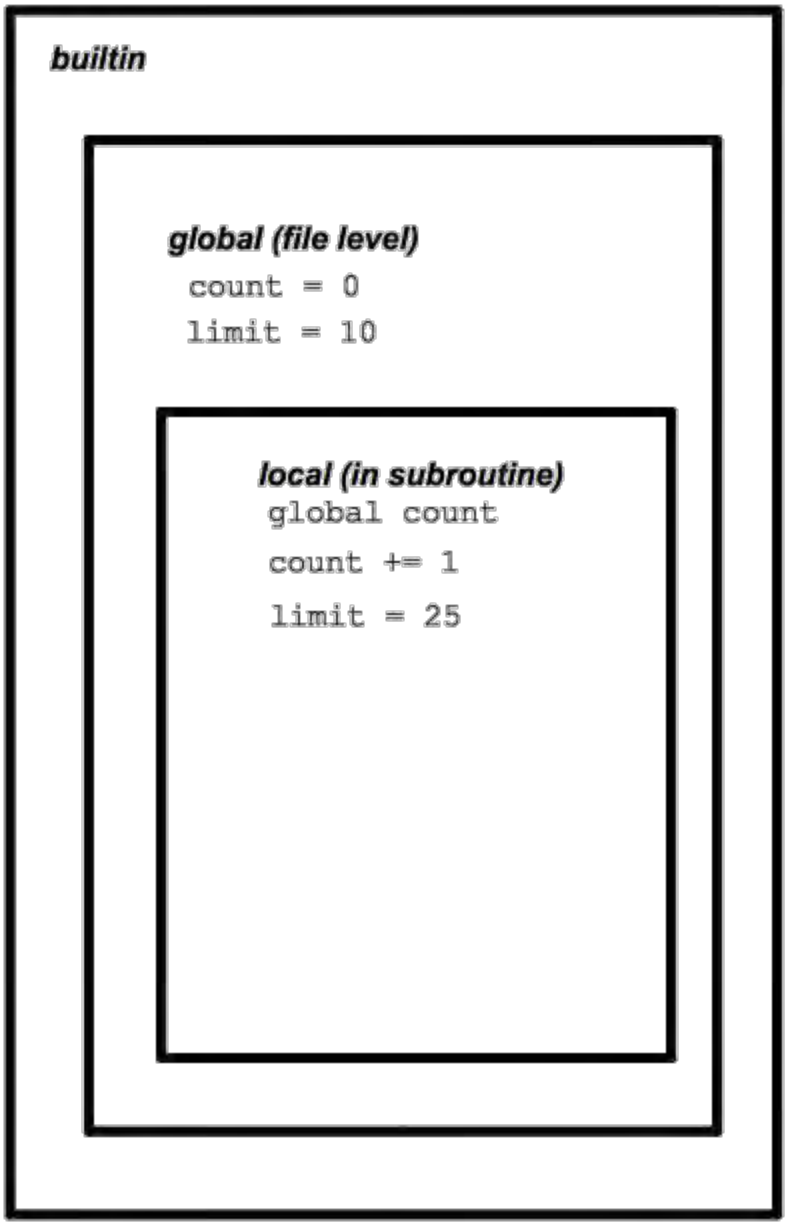
③ Uses global x since there is no local x

variable_scope.py

```
spam(): x is 22
spam(): y is wolverine

eggs(): x is 5
eggs(): y is wolverine

main: x is  5
```


builtin
global (file level)
count = 0
limit = 10
local (in subroutine)
global count
count += 1
limit = 25

The global statement

- Use **global** for assignment to global variables

What happens when you want to change a global variable? The **global** statement allows you to declare a global variable within a function. That is, when you assign to the variable, you are assigning to the global variable, instead of a local variable.

WARNING	Use of the **global** statement is discouraged, as it can make code maintenance more difficult.

Example

global_statement.py

```
#!/usr/bin/env python

x = 5


def spam():
    global x  ①
    x = 22  ②
    print("spam(): x is", x)


spam()
print("main: x is ", x)
```

① Mark x as global, not local

② Modify global variable x

global_statement.py

```
spam(): x is 22
main: x is  22
```

Chapter 7 Exercises

Exercise 7-1 (dirty_strings.py)

Using the existing script **dirty_strings.py**, write a function named **cleanup()**. This function should accept one string as input and returns a copy of the string with whitespace trimmed from the beginning and the end, and all upper case letters changed to lower case.

NOTE	The cleanup() function should not expect a list, but just one string. It should also return a single string. You should not print the cleaned-up string in the cleanup() function.

Test the function by looping through the list **spam** and printing each value before and after calling your function.

Exercise 7-2 (c2f_func.py)

Define a function named **c2f** that takes one number as a parameter, and then returns the value converted from Celsius to Fahrenheit. Test your function by calling it with the values 100, 0, 37, and -40 (one at a time, not all at once).

Example

```
f = c2f(100)
print(f)

f = c2f(-40)
print(f)
```

Exercise 7-3 (calc.py)

Write a simple four-function calculator. Repeatedly prompt the user for a math expression, which should consist of a number, an operator, and another number, all separated by whitespace. The operator may be any of "+","-", "/", or "*". For example, the user may enter "9 + 5", "4 / 28", or "12 * 5". Exit the program when the user enters "Q" or "q". (Hint: split the input into the 3 parts – first value, operator, second value).

Write a function for each operator (named "add", "subtract", etc). As each line is read, pass the two numbers to the appropriate function, based on the operator, and get the result, which is then output to the screen. The division function should check to see whether the second number is zero, and if so, return an error message, rather than trying to actually do the math.

NOTE	It is tricky to parse the expression "5+4", so just expect an expression like "5 + 4" which you can split on whitespace. To easily parse "5+4", you need the **re** (regular expressions) library.

FOR ADVANCED STUDENTS

Add more math operations; test the input to make sure it's numeric (although in real life you should use a **try** block to validate numeric conversions).

Chapter 8: Sorting

Objectives

- Sorting lists and dictionaries
- Sorting on alternate keys
- Using lambda functions
- Reversing lists

Sorting Overview

- Get a sorted copy of any sequence
- Iterables of iterables sorted item-by-item
- Sort can be customized

It is typically useful to be able to sort a collection of data. You can get a sorted copy of lists, tuples, and dictionaries.

The python sort routines sort strings character by character and it sorts numbers numerically. Mixed types cannot be sorted, since there is no valud greater than/less than comparison between different types. That is, if **s** is a string and **n** is a number, `s < n` will raise an exception.

The sort order can be customized by providing a *callback* function to calculate one or more sort keys.

What can you sort?

- list elements
- tuple elements
- string elements
- dictionary key/value pairs
- set elements

The sorted() function

- Returns a sorted copy of any collection
- Customize with named keyword parameters

```
key=
reverse=
```

The sorted() builtin function returns a sorted copy of its argument, which can be any iterable.

You can customize sorted with the **key** parameter.

Example

basic_sorting.py

```
#!/usr/bin/env python

"""Basic sorting example"""

fruits = ["pomegranate", "cherry", "apricot", "date", "Apple", "lemon", "Kiwi",
          "ORANGE", "lime", "Watermelon", "guava", "papaya", "FIG", "pear", "banana",
          "Tamarind", "persimmon", "elderberry", "peach", "BLUEberry", "lychee",
          "grape"]

sorted_fruit = sorted(fruits)  ①

print(sorted_fruit)
```

① sorted() returns a list

basic_sorting.py

```
['Apple', 'BLUEberry', 'FIG', 'Kiwi', 'ORANGE', 'Tamarind', 'Watermelon', 'apricot',
'banana', 'cherry', 'date', 'elderberry', 'grape', 'guava', 'lemon', 'lime', 'lychee',
'papaya', 'peach', 'pear', 'persimmon', 'pomegranate']
```

Custom sort keys

- Use **key** parameter
- Specify name of function to use
- Key function takes exactly one parameter
- Useful for case-insensitive sorting, sorting by external data, etc.

You can specify a function with the **key** parameter of the sorted() function. This function will be used once for each element of the list being sorted, to provide the comparison value. Thus, you can sort a list of strings case-insensitively, or sort a list of zip codes by the number of Starbucks within the zip code.

The function must take exactly one parameter (which is one element of the sequence being sorted) and return either a single value or a tuple of values. The returned values will be compared in order.

You can use any builtin Python function or method that meets these requirements, or you can write your own function.

TIP The lower() method can be called directly from the builtin object str. It takes one string argument and returns a lower case copy.

```
sorted_strings = sorted(unsorted_strings, key=str.lower)
```

Example

custom_sort_keys.py

```
#!/usr/bin/env python

fruit = ["pomegranate", "cherry", "apricot", "date", "Apple", "lemon",
         "Kiwi", "ORANGE", "lime", "Watermelon", "guava", "papaya", "FIG",
         "pear", "banana", "Tamarind", "persimmon", "elderberry", "peach",
         "BLUEberry", "lychee", "grape"]

def ignore_case(item):  ①
    return item.lower()  ②

fs1 = sorted(fruit, key=ignore_case)  ③
print("Ignoring case:")
print(" ".join(fs1), end="\n\n")

def by_length_then_name(item):
    return (len(item), item.lower())  ④

fs2 = sorted(fruit, key=by_length_then_name)
print("By length, then name:")
print(" ".join(fs2))
print()

nums = [800, 80, 1000, 32, 255, 400, 5, 5000]

n1 = sorted(nums)  ⑤
print("Numbers sorted numerically:")
for n in n1:
    print(n, end=' ')
print("\n")

n2 = sorted(nums, key=str)  ⑥
print("Numbers sorted as strings:")
for n in n2:
    print(n, end=' ')
print()
```

① Parameter is *one* element of iterable to be sorted

② Return value to sort on

③ Specify function with named parameter **key**

④ Key functions can return tuple of values to compare, in order

⑤ Numbers sort numerically by default

⑥ Sort numbers as strings

custom_sort_keys.py

```
Ignoring case:
Apple apricot banana BLUEberry cherry date elderberry FIG grape guava Kiwi lemon lime
lychee ORANGE papaya peach pear persimmon pomegranate Tamarind Watermelon

By length, then name:
FIG date Kiwi lime pear Apple grape guava lemon peach banana cherry lychee ORANGE papaya
apricot Tamarind BLUEberry persimmon elderberry Watermelon pomegranate

Numbers sorted numerically:
5 32 80 255 400 800 1000 5000

Numbers sorted as strings:
1000 255 32 400 5 5000 80 800
```

Example

sort_holmes.py

```
#!/usr/bin/env python
"""Sort titles, ignoring leading articles"""
books = [
    "A Study in Scarlet",
    "The Sign of the Four",
    "The Hound of the Baskervilles",
    "The Valley of Fear",
    "The Adventures of Sherlock Holmes",
    "The Memoirs of Sherlock Holmes",
    "The Return of Sherlock Holmes",
    "His Last Bow",
    "The Case-Book of Sherlock Holmes",
]


def strip_articles(title):  ①
    title = title.lower()
    for article in 'a ', 'an ', 'the ':
        if title.startswith(article):
            title = title[len(article):]  ②
            break
    return title


for book in sorted(books, key=strip_articles):  ③
    print(book)
```

① create function which takes element to compare and returns comparison key

② remove article by using a slice that starts after article + space `

③ sort using custom function

sort_holmes.py

```
The Adventures of Sherlock Holmes
The Case-Book of Sherlock Holmes
His Last Bow
The Hound of the Baskervilles
The Memoirs of Sherlock Holmes
The Return of Sherlock Holmes
The Sign of the Four
A Study in Scarlet
The Valley of Fear
```

Lambda functions

- Shortcut for function definition
- Create function on-the-fly
- Body must be an expression
- May take any number of parameters
- For sorting, takes one parameter

A **lambda function** is a shortcut for defining a function. The syntax is

```
lambda parameters: expression
```

The body of a lambda is restricted to being a valid Python expression; block statements and assignments are not allowed.

When using a lambda function with the **key** parameter of **sorted()**, it expects a single parameter, which is one element of the list being sorted. Lambda functions are particularly useful for sorting nested collections, such as lists of tuples.

The expression returned can be a tuple containing multiple keys, in the order in which they should be used.

Thus, the following can be used as a template:

```
lambda e: expression
```

Example

lambda_sort.py

```
#!/usr/bin/env python

fruit = ["pomegranate", "cherry", "apricot", "date", "Apple",
         "lemon", "Kiwi", "ORANGE", "lime", "Watermelon", "guava",
         "papaya", "FIG", "pear", "banana", "Tamarind", "persimmon",
         "elderberry", "peach", "BLUEberry", "lychee", "grape"]

nums = [800, 80, 1000, 32, 255, 400, 5, 5000]

fs1 = sorted(fruit, key=lambda e: e.lower())  ①
print("Ignoring case:")
print(' '.join(fs1))
print()

fs2 = sorted(fruit, key=lambda e: (len(e), e.lower()))  ②
print("By length, then name:")
print(' '.join(fs2))
print()

fs3 = sorted(nums)
print("Numbers sorted numerically:")
for n in fs3:
    print(n, end=' ')
print()
print()
```

① lambda returns key function that converts each element to lower case

② lambda returns tuple

lambda_sort.py

```
Ignoring case:
Apple apricot banana BLUEberry cherry date elderberry FIG grape guava Kiwi lemon lime
lychee ORANGE papaya peach pear persimmon pomegranate Tamarind Watermelon

By length, then name:
FIG date Kiwi lime pear Apple grape guava lemon peach banana cherry lychee ORANGE papaya
apricot Tamarind BLUEberry persimmon elderberry Watermelon pomegranate

Numbers sorted numerically:
5 32 80 255 400 800 1000 5000
```

Sorting nested data

- Collections sorted item-by-item
- Only same kind of items can be compared

You can sort a collection of collections, for instance a list of tuples. For each tuple, sorted() will compare the first element of the tuple, then the second, and so forth.

All of the items in the collection must be the same — they all must be tuples, or lists, or dicts, or strings, or anything else.

Use a lambda function, and index each element as necessary. To sort a list of tuples by the third element of each tuple, use

```
list2 = sorted(list1,key=lambda e: e[2])
```

Example

nested_sort.py

```
#!/usr/bin/env python

computer_people = [
    ('Melinda', 'Gates', 'Gates Foundation', '1964-08-15'),
    ('Steve', 'Jobs', 'Apple', '1955-02-24'),
    ('Larry', 'Wall', 'Perl', '1954-09-27'),
    ('Paul', 'Allen', 'Microsoft', '1953-01-21'),
    ('Larry', 'Ellison', 'Oracle', '1944-08-17'),
    ('Bill', 'Gates', 'Microsoft', '1955-10-28'),
    ('Mark', 'Zuckerberg', 'Facebook', '1984-05-14'),
    ('Sergey','Brin', 'Google', '1973-08-21'),
    ('Larry', 'Page', 'Google', '1973-03-26'),
    ('Linus', 'Torvalds', 'Linux', '1969-12-28'),
]



# sort by first name (default)
for first_name, last_name, organization, dob in sorted(computer_people):
    print(first_name, last_name, organization, dob  )
print('-' * 60)

# sort by last name
for first_name, last_name, organization, dob in sorted(computer_people, key=lambda e: e[
1]):  ①
    print(first_name, last_name, organization, dob)
print('-' * 60)

# sort by company
for first_name, last_name, organization, dob in sorted(computer_people, key=lambda e: e[
2]): ②
    print(first_name, last_name, organization, dob)
```

① Select element of nested tuple for sorting

② Select different element of nested tuple for sorting

nested_sort.py

```
Bill Gates Microsoft 1955-10-28
Larry Ellison Oracle 1944-08-17
Larry Page Google 1973-03-26
Larry Wall Perl 1954-09-27
Linus Torvalds Linux 1969-12-28
Mark Zuckerberg Facebook 1984-05-14
Melinda Gates Gates Foundation 1964-08-15
Paul Allen Microsoft 1953-01-21
Sergey Brin Google 1973-08-21
Steve Jobs Apple 1955-02-24
------------------------------------------------------------
Paul Allen Microsoft 1953-01-21
Sergey Brin Google 1973-08-21
Larry Ellison Oracle 1944-08-17
Melinda Gates Gates Foundation 1964-08-15
Bill Gates Microsoft 1955-10-28
Steve Jobs Apple 1955-02-24
Larry Page Google 1973-03-26
Linus Torvalds Linux 1969-12-28
Larry Wall Perl 1954-09-27
Mark Zuckerberg Facebook 1984-05-14
------------------------------------------------------------
Steve Jobs Apple 1955-02-24
Mark Zuckerberg Facebook 1984-05-14
Melinda Gates Gates Foundation 1964-08-15
Sergey Brin Google 1973-08-21
Larry Page Google 1973-03-26
Linus Torvalds Linux 1969-12-28
Paul Allen Microsoft 1953-01-21
Bill Gates Microsoft 1955-10-28
Larry Ellison Oracle 1944-08-17
Larry Wall Perl 1954-09-27
```

Sorting dictionaries

- Use dict.items()
- By default, sorts by key
- Use a lambda function or itemgetter() to sort by value

While a dictionary can't be sorted, the keys to a dictionary can. Better yet, the list of tuples returned by DICT.items() can be sorted. This list will be sorted by keys, unless you specify a key function.

Use a lambda function or operator.itemgetter() to specify the 2nd element of the key,value tuple to sort by values.

Sorting dictionary.items() is really just sorting a list of tuples.

Example

sorting_dicts.py

```
#!/usr/bin/env python

count_of = dict(red=5, green=18, blue=1, pink=0, grey=27, yellow=5)

# sort by key
for color, num in sorted(count_of.items()):  ①
    print(color, num)

print()

# sort by value
for color, num in sorted(count_of.items(), key=lambda e: e[1]): ②
    print(color, num)
```

① No special sort needed to sort by key

② Sorting by value uses second element of nested (key, value) pairs returned by items()

sorting_dicts.py

```
blue 1
green 18
grey 27
pink 0
red 5
yellow 5

pink 0
blue 1
red 5
yellow 5
green 18
grey 27
```

Sorting in reverse

- Use reverse=True

To sort in reverse, add the **reverse** parameter to sorted() or list.sort() with a true value (e.g. True).

Example

reverse_sort.py

```
#!/usr/bin/env python

fruits = ["pomegranate", "cherry", "apricot", "date", "Apple",
          "lemon", "Kiwi", "ORANGE", "lime", "Watermelon", "guava",
          "papaya", "FIG", "pear", "banana", "Tamarind", "persimmon",
          "elderberry", "peach", "BLUEberry", "lychee", "grape"]

print("reverse, case-sensitive:")
sorted_fruits = sorted(fruits, reverse=True)  ①
print(" ".join(sorted_fruits))
print()

print("reverse, case-insensitive:")
sorted_fruits = sorted(fruits, reverse=True, key=lambda e: e.lower())  ②
print(" ".join(sorted_fruits))
print()
```

① Set **reverse** to True to reverse sort

② **reverse** can be combined with key functions

reverse_sort.py

```
reverse, case-sensitive:
pomegranate persimmon pear peach papaya lychee lime lemon guava grape elderberry date
cherry banana apricot Watermelon Tamarind ORANGE Kiwi FIG BLUEberry Apple

reverse, case-insensitive:
Watermelon Tamarind pomegranate persimmon pear peach papaya ORANGE lychee lime lemon Kiwi
guava grape FIG elderberry date cherry BLUEberry banana apricot Apple
```

Sorting lists in place

- Use list.sort()
- Only for lists (not strings or tuples

To sort a list in place, use the list's sort() method. It works exactly like sorted(), except that the sort changes the order of the items in the list, and does not make a copy.

Example

sort_in_place.py

```
#!/usr/bin/env python

fruit = ["pomegranate", "cherry", "apricot", "date", "Apple", "lemon", "Kiwi", "ORANGE",
         "lime", "Watermelon", "guava", "papaya", "FIG", "pear", "banana", "Tamarind",
         "persimmon", "elderberry", "peach", "BLUEberry", "lychee", "grape"
         ]

fruit.sort(key=str.lower)  ①

print(" ".join(fruit))
```

① List is sorted in place; cannot be undone

sort_in_place.py

```
Apple apricot banana BLUEberry cherry date elderberry FIG grape guava Kiwi lemon lime
lychee ORANGE papaya peach pear persimmon pomegranate Tamarind Watermelon
```

Chapter 8 Exercises

Exercise 8-1 (scores_by_score.py)

Redo **scores.py**, printing out the students in descending order by score.

> **TIP** You will not need to change anything in **scores.py** other than the loop that prints out the names and scores.

Exercise 8-2 (alt_sorted.py)

Read in the file alt.txt. Put all the words that start with 'a' in to a file named a_sorted.txt, in sorted order. Put all the words that start with 'b' in b_sorted.txt, in reverse sorted order.

> **TIP** Read through the file once, putting lines into two lists.

Exercise 8-3 (sort_fruit.py)

Using the file fruit.txt, print it out:

- sorted by name case-sensitively (the default)
- sorted by name case-insensitively (ignoring case)
- sorted by length of name, then by name
- sorted by the 2nd letter of the name, then the first letter

Exercise 8-4 (sort_presidents.py)

Using the file presidents.txt, print out the presidents' first name, last name, and state of birth, sorted by last name, then first name.

> **TIP** Use the split() method on each line to get the individual fields.

Chapter 9: Regular Expressions

Objectives

- Creating regular expression objects
- Matching, searching, replacing, and splitting text
- Adding options to a pattern
- Replacing text with callbacks
- Specifying capture groups
- Using RE patterns without creating objects

Regular Expressions

- Specialized language for pattern matching
- Begun in UNIX; expanded by Perl
- Python adds some conveniences

> Regular expressions (or REs) are essentially a tiny, highly specialized programming language embedded inside Python and made available through the re module. Using this little language, you specify the rules for the set of possible strings that you want to match; this set might contain English sentences, or e-mail addresses, or TeX commands, or anything you like. You can then ask questions such as Does this string match the pattern?'', or Is there a match for the pattern anywhere in this string?''. You can also use REs to modify a string or to split it apart in various ways.
>
> — Python Regular Expression HOWTO

Regular expressions were first popularized thirty years ago as part of Unix text processing programs such as **vi**, **sed**, and **awk**. While they were improved incrementally over the years, it was not until the advent of Perl that they substantially changed from the originals. Perl added extensions of several different kinds – shortcuts for common sequences, look-ahead and look-behind assertions, non-greedy repeat counts, and a general syntax for embedding special constructs within the regular expression itself.

Python uses Perl-style regular expressions (AKA PCREs) and adds a few extensions of its own.

RE Syntax Overview

- Regular expressions contain branches
- Branches contain atoms
- Atoms may be quantified
- Branches and atoms may be anchored

A regular expression consists of one or more branches separated by the pipe symbol. The regular expression matches any text that is matched by any of the branches.

A branch is a left-to-right sequence of atoms. Each atom consists of either a one-character match or a parenthesized group. Each atom can have a quantifier (repeat count). The default repeat count is one.

A branch can be anchored to the beginning or end of the text. Any part of a branch can be anchored to the beginning or end of a word.

TIP There is frequently only one branch.

Two good web apps for working with Python regular expressions are
https://regex101.com/#python
http://www.pythex.org/

Table 13. Regular Expression Metacharacters

Pattern	Description
.	any character
[abc]	any character in set
[^abc]	any character not in set
\w,\W	any word, non-word char
\d,\D	any digit, non-digit
\s,\S	any space, non-space char
^,$	beginning, end of string
\b	beginning or end of word
\	escape a special character
*,+,?	0 or more, 1 or more, 0 or 1
{m}	exactly m occurrences
{m,}	at least m occurrences
{m,n}	m through n occurrences
a|b	match a or b
(?aiLmsux)	Set the A, I, L, M, S, U, or X flag for the RE (see below).
(?:…)	Non-capturing version of regular parentheses.
(?P<name>…)	The substring matched by the group is accessible by name.
(?P=name)	Matches the text matched earlier by the group named name.
(?#…)	A comment; ignored.
(?=…)	Matches if … matches next, but doesn’t consume the string.
(?!…)	Matches if … doesn’t match next.
(?⇐…)	Matches if preceded by … (must be fixed length).
(?<!…)	Matches if not preceded by … (must be fixed length).

Finding matches

- Module defines static functions
- Arguments: pattern, string

There are three primary methods for finding matches.

re.search(pattern, string)

Searches s and returns the first match. Returns a match object (**SRE_Match**) on success or **None** on failure. A match object is always evaluated as **True**, and so can be used in **if** statements and **while** loops. Call the **group()** method on a match object to get the matched text.

re.finditer(pattern, string)

Provides a match object for each match found. Normally used with a **for** loop.

re.findall(pattern, string)

Finds all matches and returns a list of matched strings.

Since regular expressions generally contain many backslashes, it is usual to specify the pattern with a raw string.

Other match methods

re.match() is like **re.search()**, but searches for the pattern at beginning of s. There is an implied ^ at the beginning of the pattern.

Likewise **re.fullmatch()** only succeeds if the pattern matches the entire string. ^ and $ around the pattern are implied.

Use the search() method unless you only want to match the beginning of the string.

Example

regex_finding_matches.py

```
#!/usr/bin/env python

import re

s = """lorem ipsum M-302 dolor sit amet, consectetur r-99 adipiscing elit, sed do
 eiusmod tempor incididunt H-476 ut labore et dolore magna Q-51 aliqua. Ut enim
ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex
ea commodo z-883  consequat. Duis aute irure dolor in reprehenderit in
voluptate velit esse cillum dolore U901 eu fugiat nulla pariatur.
Excepteur sint occaecat A-110 cupidatat non proident, sunt in H-332 culpa qui
officia deserunt Y-45 mollit anim id est laborum"""

pattern = r'[A-Z]-\d{2,3}'  ①

if re.search(pattern, s):  ②
    print("Found pattern.")
print()

m = re.search(pattern, s)  ③
print(m)
if m:
    print("Found:", m.group(0))  ④
print()

for m in re.finditer(pattern, s):  ⑤
    print(m.group())
print()

matches = re.findall(pattern, s)  ⑥
print("matches:", matches)
```

① store pattern in raw string

② search returns True on match

③ search actually returns match object

④ group(0) returns text that was matched by entire expression (or just m.group())

⑤ iterate over all matches in string:

⑥ return list of all matches

regex_finding_matches.py

```
Found pattern.

<re.Match object; span=(12, 17), match='M-302'>
Found: M-302

M-302
H-476
Q-51
A-110
H-332
Y-45

matches: ['M-302', 'H-476', 'Q-51', 'A-110', 'H-332', 'Y-45']
```

RE Objects

- **re** object contains a compiled regular expression
- Call methods on the object, with strings as parameters.

An **re** object is created by calling the compile() function, from the **re** module, with a pattern string. Once created, the object can be used for searching (matching), replacing, and splitting any string. The re.compile() function has an optional argument for flags which enable special features or fine-tune the match.

TIP	It is generally a good practice to create your re objects in a location near the top of your script, and then use them as necessary

Example

regex_objects.py

```
#!/usr/bin/env python

import re

s = """lorem ipsum M-302 dolor sit amet, consectetur r-99 adipiscing elit, sed do
 eiusmod tempor incididunt H-476 ut labore et dolore magna Q-51 aliqua. Ut enim
ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex
ea commodo z-883  consequat. Duis aute irure dolor in reprehenderit in
voluptate velit esse cillum dolore U901 eu fugiat nulla pariatur.
Excepteur sint occaecat A-110 cupidatat non proident, sunt in H-332 culpa qui
officia deserunt Y-45 mollit anim id est laborum"""

rx_code = re.compile(r'[A-Z]-\d{2,3}')  ①

if rx_code.search(s):  ②
    print("Found pattern.")
print()

m = rx_code.search(s)
if m:
    print("Found:", m.group())
print()

for m in rx_code.finditer(s):
    print(m.group())
print()

matches = rx_code.findall(s)
print("matches:", matches)
```

① Create an re (regular expression) object

② Call search() method from the object

regex_objects.py

```
Found pattern.

Found: M-302

M-302
H-476
Q-51
A-110
H-332
Y-45

matches: ['M-302', 'H-476', 'Q-51', 'A-110', 'H-332', 'Y-45']
```

Compilation Flags

- Control match
- Add features

When compiling a pattern, you can specify various flags to control how the match occurs. The flags are aliases for numeric values, and can be combined by ORing them together Each flag has a short for and a long form.

re.I, re.IGNORECASE

Perform case-insensitive matching; character class and literal strings will match letters by ignoring case. For example, [A-Z] will match lowercase letters, too, and Spam will match "Spam", "spam", or "spAM". This lower-casing doesn't take the current locale into account; it will if you also set the LOCALE flag.

re.L, re.LOCALE

Make \w, \W, \b, and \B, dependent on the current locale.

Locales are a feature of the C library intended to help in writing programs that take account of language differences. For example, if you're processing French text, you'd want to be able to write \w+ to match words, but \w only matches the character class [A-Za-z]; it won't match "é" or "ç". If your system is configured properly and a French locale is selected, certain C functions will tell the program that "é" should also be considered a letter. Setting the LOCALE flag enables \w+ to match French words as you'd expect.

re.M, re.MULTILINE

Usually ^ matches only at the beginning of the string, and $ matches only at the end of the string and immediately before the newline (if any) at the end of the string. When this flag is specified, ^ matches at the beginning of the string and at the beginning of each line within the string, immediately following each newline. Similarly, the $ metacharacter matches either at the end of the string and at the end of each line (immediately preceding each newline).

re.S, re.DOTALL

Makes the "." special character match any character at all, including a newline; without this flag, "." will match anything except a newline.

re.X, re.VERBOSE

This flag allows you to write regular expressions that are more readable by granting you more flexibility in how you can format them. When this flag has been specified, whitespace within the RE string is ignored, except when the whitespace is in a character class or preceded by an unescaped backslash; this lets you organize and indent the RE more clearly. It also enables you to put comments within a RE that will be ignored by the engine; comments are marked by a "#" that's neither in a character class or preceded by an unescaped backslash. Use a triple-quoted string for your pattern to make best advantage of this flag.

Example

regex_flags.py

```
#!/usr/bin/env python

import re

s = """lorem ipsum M-302 dolor sit amet, consectetur r-99 adipiscing elit, sed do
 eiusmod tempor incididunt H-476 ut labore et dolore magna Q-51 aliqua. Ut enim
ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex
ea commodo z-883  consequat. Duis aute irure dolor in reprehenderit in
voluptate velit esse cillum dolore U901 eu fugiat nulla pariatur.
Excepteur sint occaecat A-110 cupidatat non proident, sunt in H-332 culpa qui
officia deserunt Y-45 mollit anim id est laborum"""

pattern = r'[A-Z]-\d{2,3}'

if re.search(pattern, s, re.IGNORECASE):  ①
    print("Found pattern.")
print()

m = re.search(pattern, s, re.I | re.M)  ②
if m:
    print("Found:", m.group())
print()

for m in re.finditer(pattern, s, re.I):
    print(m.group())
print()

matches = re.findall(pattern, s, re.I)
print("matches:", matches)
```

① make search case-insensitive

② short version of flag

regex_flags.py

```
Found pattern.

Found: M-302

M-302
r-99
H-476
Q-51
z-883
A-110
H-332
Y-45

matches: ['M-302', 'r-99', 'H-476', 'Q-51', 'z-883', 'A-110', 'H-332', 'Y-45']
```

Groups

- Marked with parentheses
- Capture whatever matched pattern within
- Access with match.group()

Frequently you need to obtain more information than just whether the RE matched or not. Regular expressions are often used to dissect strings by writing a RE divided into several subgroups which match different components of interest. For example, an RFC-822 header line is divided into a header name and a value, separated by a ":". This can be handled by writing a regular expression which matches an entire header line, and has one group which matches the header name, and another group which matches the header's value.

Groups are marked with parentheses, and 'capture' whatever matched the pattern inside the parentheses.

re.findall() returns a list of tuples, where each tuple contains the match for each group.

To access groups in more detail, use **finditer()** and call the **group()** method on each match object. The default group is 0, which is always the entire match. It can be retrieved with either ***match*.group(0)**, or just ***match*.group()**. ***match*.group(1)** returns text matched by the first set of parentheses, ***match*.group(2)** returns the text from the second set, etc.

In the same vein, ***match*.start()** or ***match*.start(0)** return the beginning 0-based offset of the entire match; ***match*.start(1)** returns the beginning offset of group 1, and so forth. The same is true for ***match*.end()** and ***match*.end(n)**.

***match*.span()** returns the the start and end offsets for the entire match. ***match*.span(1)** returns start and end offsets for group 1, and so forth.

Example

regex_group.py

```
#!/usr/bin/env python

import re

s = """lorem ipsum M-302 dolor sit amet, consectetur r-99 adipiscing elit, sed do
 eiusmod tempor incididunt H-476 ut labore et dolore magna Q-51 aliqua. Ut enim
ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex
ea commodo z-883  consequat. Duis aute irure dolor in reprehenderit in
voluptate velit esse cillum dolore U901 eu fugiat nulla pariatur.
Excepteur sint occaecat A-110 cupidatat non proident, sunt in H-332 culpa qui
officia deserunt Y-45 mollit anim id est laborum"""

pattern = r'([A-Z])-(\d{2,3})'  ①

for m in re.finditer(pattern, s):
    print(m.group(0), m.group(1), m.group(2))  ②
    print(m.start(1), m.end(1), m.span())
print()

matches = re.findall(pattern, s)  ③
print("matches:", matches)
```

① parens delimit groups

② group 1 is first group, etc. (group 0 is entire match)

③ findall() returns list of tuples containing groups

regex_group.py

```
M-302 M 302
12 13 (12, 17)
H-476 H 476
102 103 (102, 107)
Q-51 Q 51
134 135 (134, 138)
A-110 A 110
398 399 (398, 403)
H-332 H 332
436 437 (436, 441)
Y-45 Y 45
470 471 (470, 474)

matches: [('M', '302'), ('H', '476'), ('Q', '51'), ('A', '110'), ('H', '332'), ('Y',
'45')]
```

Special Groups

- Non-capture groups are used just for grouping
- Named groups allow retrieval of sub-expressions by name rather than number
- Look-ahead and look-behind match, but do not capture

There are two variations on RE groups that are useful. If the first character inside the group is a question mark, then the parentheses contain some sort of extended pattern, designated by the next character after the question mark. The most basic is (?:pattern), which groups but does not capture.

A welcome addition in Python is the concept of named groups. Instead of remembering that the month is the 3rd group and the year is the 4th group, you can use the syntax (?P<name>pattern). You can then call match.group("name") to fetch the text match by that sub-expression; alternatively, you can call match.groupdict(), which returns a dictionary where the keys are the pattern names, and the values are the text matched by each pattern.

Another advanced concept is an assertion, either lookahead or lookbehind. A lookahead assertion uses the syntax (?=pattern). The string being matched must match the lookahead, but does not become part of the overall match.

For instance, "\d(?st|nd|rd|th)(?=street)" matches "1st", "2nd", etc., but only where they are followed by "street".

Example

regex_special.py

```
#!/usr/bin/env python

import re

s = """lorem ipsum M-302 dolor sit amet, consectetur r-99 adipiscing elit, sed do
 eiusmod tempor incididunt H-476 ut labore et dolore magna Q-51 aliqua. Ut enim
ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex
ea commodo z-883  consequat. Duis aute irure dolor in reprehenderit in
voluptate velit esse cillum dolore U901 eu fugiat nulla pariatur.
Excepteur sint occaecat A-110 cupidatat non proident, sunt in H-332 culpa qui
officia deserunt Y-45 mollit anim id est laborum"""

pattern = r'(?P<letter>[A-Z])-(?P<number>\d{2,3})'  ①

for m in re.finditer(pattern, s):
    print(m.group('letter'), m.group('number'))  ②
```

① Use (?<NAME>...) to name groups

② Use m.group(NAME) to retrieve text

regex_special.py

```
M 302
H 476
Q 51
A 110
H 332
Y 45
```

Replacing text

- Use RE.sub(replacement,string[,count])
- RE.subn() returns tuple with string and count

To find and replace text using a regular expression, use the sub() method. It takes the replacement text and the string to search as arguments, and returns the modified string.

The third, optional argument is the maximum number of replacements to make.

Be sure to put the arguments in the proper order!

Example

regex_sub.py

```
#!/usr/bin/env python

import re

s = """lorem ipsum M-302 dolor sit amet, consectetur r-99 adipiscing elit, sed do
 eiusmod tempor incididunt H-476 ut labore et dolore magna Q-51 aliqua. Ut enim
ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex
ea commodo z-883  consequat. Duis aute irure dolor in reprehenderit in
voluptate velit esse cillum dolore U901 eu fugiat nulla pariatur.
Excepteur sint occaecat A-110 cupidatat non proident, sunt in H-332 culpa qui
officia deserunt Y-45 mollit anim id est laborum"""

rx_code = re.compile(r'(?P<letter>[A-Z])-(?P<number>\d{2,3})', re.I)

s2 = rx_code.sub("[REDACTED]", s) ①
print(s2)
print()

s3, count = rx_code.subn("___", s) ②
print("Made {} replacements".format(count))
print(s3)
```

① replace pattern with string

② subn returns tuple with result string and replacement count

regex_sub.py

```
lorem ipsum [REDACTED] dolor sit amet, consectetur [REDACTED] adipiscing elit, sed do
 eiusmod tempor incididunt [REDACTED] ut labore et dolore magna [REDACTED] aliqua. Ut
enim
ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex
ea commodo [REDACTED]  consequat. Duis aute irure dolor in reprehenderit in
voluptate velit esse cillum dolore U901 eu fugiat nulla pariatur.
Excepteur sint occaecat [REDACTED] cupidatat non proident, sunt in [REDACTED] culpa qui
officia deserunt [REDACTED] mollit anim id est laborum

Made 8 replacements
lorem ipsum ___ dolor sit amet, consectetur ___ adipiscing elit, sed do
 eiusmod tempor incididunt ___ ut labore et dolore magna ___ aliqua. Ut enim
ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex
ea commodo ___  consequat. Duis aute irure dolor in reprehenderit in
voluptate velit esse cillum dolore U901 eu fugiat nulla pariatur.
Excepteur sint occaecat ___ cupidatat non proident, sunt in ___ culpa qui
officia deserunt ___ mollit anim id est laborum
```

Replacing with a callback

- Replacement can be function
- Function expects match object, returns replacement text
- Use normally defined function or a lambda

In addition to using a string as the replacement, you can specify a function. This function will be called once for each match, with the match object as its only parameter.

Whatever string the function returns will be used as the replacement text. This lets you have complete control over the replacement.

Using a callback makes it simple to:

- preservecase in a replacement
- add text around the replacement
- look up the text in a dictionary or database to find replacement text

Example

regex_sub_callback.py

```
#!/usr/bin/env python

import re

s = """lorem ipsum M302 dolor sit amet, consectetur r99 adipiscing elit, sed do
 eiusmod tempor incididunt H476 ut labore et dolore magna Q51 aliqua. Ut enim
ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex
ea commodo Z883  consequat. Duis aute irure dolor in reprehenderit in
voluptate velit esse cillum dolore U901 eu fugiat nulla pariatur.
Excepteur sint occaecat A110 cupidatat non proident, sunt in H332 culpa qui
officia deserunt Y45 mollit anim id est laborum"""

rx_code = re.compile(r'(?P<letter>[A-Z])(?P<number>\d{2,3})', re.I)

def update_code(m):  ①
    letter = m.group('letter').upper()
    number = int(m.group('number'))
    return '{}:{:04d}'.format(letter, number)  ②


s2 = rx_code.sub(update_code, s)  ③
print(s2)
```

① callback function is passed each match object

② function returns replacement text

③ sub takes callback function instead of replacement text

regex_sub_callback.py

```
lorem ipsum M:0302 dolor sit amet, consectetur R:0099 adipiscing elit, sed do
 eiusmod tempor incididunt H:0476 ut labore et dolore magna Q:0051 aliqua. Ut enim
ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex
ea commodo Z:0883  consequat. Duis aute irure dolor in reprehenderit in
voluptate velit esse cillum dolore U:0901 eu fugiat nulla pariatur.
Excepteur sint occaecat A:0110 cupidatat non proident, sunt in H:0332 culpa qui
officia deserunt Y:0045 mollit anim id est laborum
```

Splitting a string

- Syntax: re.split(string[,max])

The re.split() method splits a string into pieces, returning the pieces as a list. The optional max argument limits the numbers of pieces.

Example

regex_split.py

```
#!/usr/bin/env python

import re

rx_wordsep = re.compile(r"[^a-z]+", re.I)  ①

s1 = '''There are 10 kinds of people in a Binary world, I hear" -- Geek talk'''

words = rx_wordsep.split(s1)  ②
print(words)
```

① When splitting, pattern matches what you **don't** want

② Retrieve text *separated* by your pattern

regex_split.py

```
['There', 'are', 'kinds', 'of', 'people', 'in', 'a', 'Binary', 'world', 'I', 'hear',
'Geek', 'talk']
```

Chapter 9 Exercises

Exercise 9-1 (pyfind.py)

Write a script which takes two or more arguments. The first argument is the pattern to search for; the remaining arguments are files to search. For each file, print out all lines which match the pattern.1

Exercise 9-2 (mark_big_words.py)

Copy parrot.txt to bigwords.txt adding asterisks around all words that are 8 or more characters long.

HINT: Use the \b anchor to indicate beginning and end of a word.

Exercise 9-3 (print_numbers.py)

Write a script to print out all lines in custinfo.dat which contain phone numbers.

Exercise 9-4 (word_freq.py)

Write a script that will read a text file and print out a list of all the words in the file, normalized to lower case, and with the number of times that word occurred in the file. Use the regular expression [^\w']+ for splitting each line into words.

Test with any of the text files in the DATA folder.

Chapter 10: Using the Standard Library

Objectives

- Overview of the standard library
- Getting information on the Python interpreter's environment
- Running external programs
- Walking through a directory tree
- Working with path names
- Calculating dates and times
- Fetching data from a URL
- Generating random values

The sys module

- Import the sys module to provide access to the interpreter and its environment
- Get interpreter attributes
- Interact with the operating system

The sys module provides access to some objects used or maintained by the interpreter and to functions that interact strongly with the interpreter.

This module provides details of the current Python interpreter; it also provides objects and methods to interact with the operating system.

Even though the sys module is built into the Python interpreter, it must be imported like any other module.

Interpreter Information

- sys provides details of interpreter

To get the folder where Python is installed, use **sys.prefix**.

To get the path to the Python executable, use **sys.executable**.

To get a version string, use **sys.version**.

To get the details of the interpreter as a tuple, use **sys.version_info**.

To get the list of directories that will be searched for modules, examine **sys.path**.

To get a list of currently loaded modules, use **sys.modules**.

To find out what platform (OS/architecture) the script is running on, use **sys.platform**.

STDIO

- stdin
- stdout
- stderr

The sys object defines three file objects representing the three streams of STDIO, or "standard I/O".

Unless they have been redirected, sys.stdin is the keyboard, and sys.stdout and sys.stderr are the console screen. You should use sys.stderr for error messages.

Example

stdio.py

```
#!/usr/bin/env python

import sys
sys.stdout.write("Hello, world\n")
sys.stderr.write("Error message here...\n")
```

stdio.py 2>spam.txt

```
Hello, world
```

type spam.txt *windows*

cat spam.txt *non-windows*

```
Error message here...
```

Launching external programs

- Different ways to launch programs
  - Just launch (use system())
  - Capture output (use popen())
- import os module
- Use system() or popen() methods

In Python, you can launch an external command using the os module functions os.system() and os.popen().

os.system() launches any external command, as though you had typed it at a command prompt. popen() opens a pipe to a command so you can read the output of the command one line at a time. popen() is very similar to the open() function; it returns an iterable object.

For more control over external processes, use the **subprocess** module (part of the standard library), or check out the sh module (not part of the standard library).

Example

external_programs.py

```
#!/usr/bin/env python
import os

os.system("hostname")  ①

with os.popen('netstat -an') as netstat_in:  ②
    for entry in netstat_in:  ③
        if 'ESTAB' in entry:  ④
            print(entry, end='')
print()
```

① Just run "hostname"

② Open command line "netstat -an" as a file-like object

③ Iterate over lines in output of "netstat -an"

④ Check to see if line contains "ESTAB"

external_programs.py

```
Johns-Macbook.attlocal.net
tcp4       0      0  192.168.1.242.50686    64.68.120.47.443       ESTABLISHED
tcp6       0      0  2600:1700:3901:6.50682 2a03:2880:f011:1.443   ESTABLISHED
tcp6       0      0  2600:1700:3901:6.50678 2607:f8b0:4000:8.443   ESTABLISHED
tcp6       0      0  2600:1700:3901:6.50661 2607:f8b0:4002:c.443   ESTABLISHED
tcp6       0      0  2600:1700:3901:6.50657 2a03:2880:f011:1.443   ESTABLISHED
tcp4       0      0  192.168.1.242.50630    140.82.114.25.443      ESTABLISHED
tcp4       0      0  192.168.1.242.49817    162.247.243.146.443    ESTABLISHED
tcp6       0      0  2600:1700:3901:6.49795 2a03:2880:f011:1.443   ESTABLISHED
tcp4       0      0  192.168.1.242.49728    209.197.219.155.443    ESTABLISHED
tcp4       0      0  192.168.1.242.49724    216.151.147.132.443    ESTABLISHED
tcp4       0      0  192.168.1.242.49723    216.151.147.132.443    ESTABLISHED
tcp4       0      0  192.168.1.242.49341    162.247.243.146.443    ESTABLISHED
tcp6       0      0  2600:1700:3901:6.49334 2607:f8b0:4023:1.5228  ESTABLISHED
tcp4       0      0  192.168.1.242.57989    34.105.102.6.80        ESTABLISHED
```

Paths, directories and filenames

- import os.path module
- path is mapped to appropriate package for current os
- The os.path module provides many functions for working with paths.
- Some of the more common methods:
  - os.path.exists()
  - os.path.dirname()
  - os.path.basename
  - os.path.split()

os.path is the primary module for working with filenames and paths. There are many methods for getting and modifying a file or folder's path.

Also provide are methods for getting information about a file.

Example

paths.py

```
#!/usr/bin/env python
import sys
import os.path

unix_p1 = "bin/spam.txt"  ①
unix_p2 = "/usr/local/bin/ham"  ②

win_p1 = r"spam\ham.doc"  ③
win_p2 = r"\\spam\ham\eggs\toast\jam.doc"  ④

if sys.platform == 'win32':  ⑤
    print("win_p1:", win_p1)
    print("win_p2:", win_p2)
    print("dirname(win_p1):", os.path.dirname(win_p1))  ⑥
    print("dirname(win_p2):", os.path.dirname(win_p2))
    print("basename(win_p1):", os.path.basename(win_p1))  ⑦
    print("basename(win_p2):", os.path.basename(win_p2))
    print("isabs(win_p1):", os.path.isabs(win_p1))  ⑧
    print("isabs(win_p2):", os.path.isabs(win_p2))
else:
    print("unix_p1:", unix_p1)
    print("unix_p2:", unix_p2)
    print("dirname(unix_p1):", os.path.dirname(unix_p1))  ⑥
    print("dirname(unix_p2):", os.path.dirname(unix_p2))
    print("basename(unix_p1):", os.path.basename(unix_p1))  ⑦
    print("basename(unix_p2):", os.path.basename(unix_p2))
    print("isabs(unix_p1):", os.path.isabs(unix_p1))  ⑧
    print("isabs(unix_p2):", os.path.isabs(unix_p2))
    print(
        'format("cp spam.txt {}".format(os.path.expanduser("~"))):',  ⑨
        format("cp spam.txt {}".format(os.path.expanduser("~"))),
    )
    print(
        'format("cd {}".format(os.path.expanduser("~root"))):',  ⑩
        format("cd {}".format(os.path.expanduser("~root"))),
    )
```

① Unix relative path

② Unix absolute path

③ Windows relative path

④ Windows UNC path

⑤ What platform are we on?

⑥ Just the folder name

⑦ Just the file (or folder) name

⑧ Is it an absolute path?

⑨ ~ is current user's home

⑩ ~NAME is NAME's home

paths.py

```
unix_p1: bin/spam.txt
unix_p2: /usr/local/bin/ham
dirname(unix_p1): bin
dirname(unix_p2): /usr/local/bin
basename(unix_p1): spam.txt
basename(unix_p2): ham
isabs(unix_p1): False
isabs(unix_p2): True
format("cp spam.txt {}".format(os.path.expanduser("~"))): cp spam.txt /Users/jstrick
format("cd {}".format(os.path.expanduser("~root"))): cd /var/root
```

paths.py (windows)

```
dirname(win_p1):  \\marmoset\sharing\technology\docs\bonsai
dirname(win_p2):  \\marmoset\sharing\technology\docs\bonsai
basename(win_p1):  foo.doc
basename(win_p2):  foo.doc
os.path.split(win_p1) Head: \\marmoset\sharing\technology\docs\bonsai Tail: foo.doc
os.path.split(win_p1) Head: bonsai Tail: foo.doc
os.path.splitunc(win_p1) Head: \\marmoset\sharing Tail: \technology\docs\bonsai\foo.doc
os.path.splitunc(win_p1) Head:  Tail: bonsai\foo.doc
```

Walking directory trees

- Import os module
- Use the os.walk() iterator
- Returns tuple for each directory starting with the specified top directory
- Tuple contains full path to directory, list of subdirectories, and list of files *syntax:

```
for currdir,subdirs,files in os.walk("start-dir"):
      pass
```

The os.walk() method provides a way to easily walk a directory tree. It provides an iterator for a directory and all its subdirectories. For each directory, it returns a tuple with three values.

The first element is the full (absolute) path to the directory; the second element is a list of the directory's subdirectories (relative names); the third element is a list of the non-directory files in the subdirectory (also relative names).

TIP Remember to not use "dir" or "file" as variables when looping through the iterator, because they will overwrite builtins.

Example

os_walk.py

```
#!/usr/bin/env python

# count number of files and dirs in  a directory tree
# note "files" includes devices, symbolic links, and pipes
import os
import sys

if sys.platform == 'win32':  ①
    target = 'C:/Users'
else:
    target = '/etc'

total_files = 0  ②
total_dirs = 0

for currdir, subdirs, files in os.walk(target):  ③
    total_dirs += 1  # increment number of directories seen
    total_files += len(files)  # add the number of files in this dir

print("{} contains {} dirs and {} files".format(target, total_dirs, total_files))  ④
```

os_walk.py

```
/etc contains 38 dirs and 343 files
```

os_walk2.py

```
#!/usr/bin/env python
"""
    find files whose size is greater than or equal to specified number of bytes
"""
import sys
import os

MINIMUM_SIZE = 1000

if len(sys.argv) < 2: ①
    print('Syntax: walk2.py START-DIR')
    sys.exit(1)

for currdir, subdirs, files in os.walk(sys.argv[1]):
    for file in files: ②
        fullpath = os.path.join(currdir, file) ③
        if os.path.isfile(fullpath): ④
            fsize = os.path.getsize(fullpath) ⑤
            if fsize >= MINIMUM_SIZE: ⑥
                print("{:40s} {:8d}".format(fullpath, fsize))
```

os_walk2.py

```
./xml_from_presidents.py                  2458
./boto3_create_folders.py                 1324
./dc_carddeck.py                          1595
./paramiko_remote_cmd.py                  1217
./presidents_hidden_sheet.xlsx           11186
./sa_movie_models.py                      1349
./example.zip                            56345
./xml_create_knights.py                   1396
./.pylintrc                              14755
./db_mysql_metadata.py                    1431
```

...

Grabbing data from the web

- import module urllib
- urlopen() similar to open()
- Iterate through (or read from) URL object
- Use info() method for metadata

Python makes grabbing web pages easy with the urllib module. The urllib.request.urlopen() method returns an HTTP response object (which also acts like a file object).

Iterating through this object returns the lines in the specified web page (the same lines you would see with "view source" in a browser).

Since the URL is opened in binary mode; you can use *response*.read() to download any kind of file which a URL represents – PDF, MP3, JPG, and so forth.

NOTE	Grabbing web pages is even easier with the **requests** modules. See **read_html_requests.py** and **read_pdf_requests.py** in the EXAMPLES folder.

Example

read_html_urllib.py

```
#!/usr/bin/env python

import urllib.request

u = urllib.request.urlopen("https://www.python.org")

print(u.info())  ①
print()

print(u.read(500).decode())   ②
```

① .info() returns a dictionary of HTTP headers

② The text is returned as a bytes object, so it needs to be decoded to a string

read_html_urllib.py

```
Connection: close
Content-Length: 50798
Server: nginx
Content-Type: text/html; charset=utf-8
X-Frame-Options: DENY
Via: 1.1 vegur, 1.1 varnish, 1.1 varnish
Accept-Ranges: bytes
Date: Wed, 03 Nov 2021 14:17:55 GMT
Age: 1474
X-Served-By: cache-bwi5178-BWI, cache-pdk17841-PDK
X-Cache: HIT, HIT
X-Cache-Hits: 1, 1
X-Timer: S1635949075.092198,VS0,VE1
Vary: Cookie
Strict-Transport-Security: max-age=63072000; includeSubDomains



<!doctype html>
<!--[if lt IE 7]>   <html class="no-js ie6 lt-ie7 lt-ie8 lt-ie9">   <![endif]-->
<!--[if IE 7]>      <html class="no-js ie7 lt-ie8 lt-ie9">          <![endif]-->
<!--[if IE 8]>      <html class="no-js ie8 lt-ie9">                 <![endif]-->
<!--[if gt IE 8]><!--><html class="no-js" lang="en" dir="ltr">  <!--<![endif]-->

<head>
    <meta charset="utf-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">

    <link rel="prefetch" href="//ajax.googleapis.com/ajax/libs/jqu
```

...

Example

read_pdf_urllib.py

```
#!/usr/bin/env python

import sys
import os
from urllib.request import urlopen
from urllib.error import HTTPError

# url to download a PDF file of a NASA ISS brochure

url = 'https://www.nasa.gov/pdf/739318main_ISS%20Utilization%20Brochure
%202012%20Screenres%203-8-13.pdf'  ①

saved_pdf_file = 'nasa_iss.pdf'  ②

try:
    URL = urlopen(url)  ③
except HTTPError as e:  ④
    print("Unable to open URL:", e)
    sys.exit(1)

pdf_contents = URL.read()  ⑤
URL.close()

with open(saved_pdf_file, 'wb') as pdf_in:
    pdf_in.write(pdf_contents)  ⑥

if sys.platform == 'win32':  ⑦
    cmd = saved_pdf_file
elif sys.platform == 'darwin':
    cmd = 'open ' + saved_pdf_file
else:
    cmd = 'acroread ' + saved_pdf_file

os.system(cmd)  ⑧
```

Sending email

- use smtplib
- For attachments, use email.mime.*
- Can provide authentication
- Can work with proxies

It is easy to send a simple email message with Python. The smtplib module allows you to create and send the message.

To send an attachment, use smptlib plus one or more of the submodules of email.mime, which are needed to put the message and attachments in proper MIME format.

TIP When sending attachments, be sure to use the .as_string() method on the MIME message object. Otherwise you will be sending binary gibberish to your recipient.

Example

email_simple.py

```
#!/usr/bin/env python
from getpass import getpass  ①
import smtplib  ②
from email.message import EmailMessage  ③
from datetime import datetime

TIMESTAMP = datetime.now().ctime()  ④

SENDER = 'jstrick@mindspring.com'
RECIPIENTS = ['jstrickler@gmail.com']
MESSAGE_SUBJECT = 'Python SMTP example'

MESSAGE_BODY = """
Hello at {}.

Testing email from Python
""".format(TIMESTAMP)

SMTP_USER = 'pythonclass'
SMTP_PASSWORD = getpass("Enter SMTP server password:")  ⑤

smtpserver = smtplib.SMTP("smtp2go.com", 2525)  ⑥
smtpserver.login(SMTP_USER, SMTP_PASSWORD)  ⑦

msg = EmailMessage()  ⑧
msg.set_content(MESSAGE_BODY)  ⑨
msg['Subject'] = MESSAGE_SUBJECT  ⑩
msg['from'] = SENDER  ⑪
msg['to'] = RECIPIENTS  ⑫

try:
    smtpserver.send_message(msg)  ⑬
except smtplib.SMTPException as err:
    print("Unable to send mail:", err)
finally:
    smtpserver.quit()  ⑭
```

① module for hiding password

② module for sending email

③ module for creating message

④ get a time string for the current date/time

⑤ get password (not echoed to screen)

⑥ connect to SMTP server

⑦ log into SMTP server

⑧ create empty email message

⑨ add the message body

⑩ add the message subject

⑪ add the sender address

⑫ add a list of recipients

⑬ send the message

⑭ disconnect from SMTP server

email_attach.py

```
#!/usr/bin/env python
import smtplib
from datetime import datetime
from imghdr import what  ①
from email.message import EmailMessage ②
from getpass import getpass ③


SMTP_SERVER = "smtp2go.com"  ④
SMTP_PORT = 2525

SMTP_USER = 'pythonclass'

SENDER = 'jstrick@mindspring.com'
RECIPIENTS = ['jstrickler@gmail.com']


def main():
    smtp_server = create_smtp_server()
    now = datetime.now()
    msg = create_message(
        SENDER,
        RECIPIENTS,
        'Here is your attachment',
        'Testing email attachments from python class at {}\n\n'.format(now),
    )
    add_text_attachment('../DATA/parrot.txt', msg)
    add_image_attachment('../DATA/felix_auto.jpeg', msg)
    send_message(smtp_server, msg)


def create_message(sender, recipients, subject, body):
    msg = EmailMessage()  ⑤
    msg.set_content(body)  ⑥
    msg['From'] = sender
    msg['To'] = recipients
    msg['Subject'] = subject
    return msg


def add_text_attachment(file_name, message):
    with open(file_name) as file_in:  ⑦
        attachment_data = file_in.read()
    message.add_attachment(attachment_data)  ⑧
```

```
def add_image_attachment(file_name, message):
    with open(file_name, 'rb') as file_in:  ⑨
        attachment_data = file_in.read()
    image_type = what(None, h=attachment_data)  ⑩
    message.add_attachment(attachment_data, maintype='image', subtype=image_type)  ⑪


def create_smtp_server():
    password = getpass("Enter SMTP server password:")  ⑫
    smtpserver = smtplib.SMTP(SMTP_SERVER, SMTP_PORT)  ⑬
    smtpserver.login(SMTP_USER, password)  ⑭

    return smtpserver


def send_message(server, message):
    try:
        server.send_message(message)  ⑮
    finally:
        server.quit()


if __name__ == '__main__':
    main()
```

① module to determine image type

② module for creating email message

③ module for reading password privately

④ global variables for external information (IRL should be from environment — command line, config file, etc.)

⑤ create instance of EmailMessage to hold message

⑥ set content (message text) and various headers

⑦ read data for text attachment

⑧ add text attachment to message

⑨ read data for binary attachment

⑩ get type of binary data

⑪ add binary attachment to message, including type and subtype (e.g., "image/jpg)"

⑫ get password from user (don’t hardcode sensitive data in script)

⑬ create SMTP server connection

⑭ log into SMTP connection

⑮ send message

math functions

- use the math module
- Provides functions and constants

Python provides many math functions. It also provides constants pi and e.

Table 14. Math functions

sqrt(x)	Returns the square root of x
exp(x)	Return ex
log(x)	Returns the natural log, i.e. lnx
log10(x)	Returns the log to the base 10 of x
sin(x)	Returns the sine of x
cos(x)	Return the cosine of x
tan(x)	Returns the tangent of x
asin(x)	Return the arc sine of x
acos(x)	Return the arc cosine of x
atan(x)	Return the arc tangent of x
fabs(x)	Return the absolute value, i.e. the modulus, of x
ceil(x)	Rounds x (which is a float) up to next highest integer1
floor(x)	Rounds x (which is a float) down to next lowest integer
degrees(x)	converts angle x from radians to degrees
radians(x)	converts angle x from degrees to radians

TIP This table is not comprehensive – see docs for math module for some more functions.

For more math and engineering functions, see the external modules numpy and scipy.

Random values

- Use the random module
- Useful methods
  - random()
  - randint(start,stop)
  - randrange(start,limit)
  - choice(seq)
  - sample(seq,count)
  - shuffle(seq)

The random module provides methods based on selected a random number. In addition to random(), which returns a fractional number between 0 and 1, there are a number of convenience functions.

randint() and randrange() return a random integer within a range of numbers; the difference is that randint() includes the endpoint of the specified range, and randrange() does not.

choice() returns one element from any of Python's sequence types; sample() is the same, but returns a specified number of elements.

shuffle() randomizes a sequence.

Example

random_ex.py

```
#!/usr/bin/env python

import random

fruits = ["pomegranate", "cherry", "apricot", "date", "apple",
"lemon", "kiwi", "orange", "lime", "watermelon", "guava",
"papaya", "fig", "pear", "banana", "tamarind", "persimmon",
"elderberry", "peach", "blueberry", "lychee", "grape"]


for i in range(10):
    print("random():", random.random())
    print("randint(1, 2000):", random.randint(1, 2000))
    print("randrange(1, 5):", random.randrange(1, 10))
    print("choice(fruit):", random.choice(fruits))
    print("sample(fruit, 3):", random.sample(fruits, 3))
    print()
```

random_ex.py

```
random(): 0.9000455123129949
randint(1, 2000): 1811
randrange(1, 5): 4
choice(fruit): blueberry
sample(fruit, 3): ['date', 'apple', 'kiwi']

random(): 0.16370354395367936
randint(1, 2000): 556
randrange(1, 5): 7
choice(fruit): orange
sample(fruit, 3): ['lychee', 'blueberry', 'grape']

random(): 0.06119845803103441
randint(1, 2000): 1591
randrange(1, 5): 3
choice(fruit): lemon
sample(fruit, 3): ['apple', 'fig', 'cherry']

random(): 0.5778150891802429
randint(1, 2000): 946
randrange(1, 5): 7
choice(fruit): grape
sample(fruit, 3): ['lime', 'apple', 'persimmon']

random(): 0.9734256016137639
randint(1, 2000): 1237
randrange(1, 5): 2
choice(fruit): grape
sample(fruit, 3): ['persimmon', 'watermelon', 'kiwi']
```

Dates and times

- Use the datetime module
- Provides several classes
  - datetime
  - date
  - time
  - timedelta

Python provides the datetime module for manipulating dates and times. Once you have created date or time objects, you can combines them and extract the time units you need.

Example

datetime_ex.py

```
#!/usr/bin/env python

from datetime import datetime, date, timedelta

today = date.today()
print("today:", today)  ①
print("type(today): {}".format(type(today)))
print("today.month: {}".format(today.month))
print("today.day: {}".format(today.day))
print("today.year: {}".format(today.year))
print()



now = datetime.now()  ②
print("now: {}".format(now))
print("now.day:", now.day)  ③
print("now.month:", now.month)
print("now.year:", now.year)
print("now.hour:", now.hour)
print("now.minute:", now.minute)
print("now.second:", now.second)
print("now.microsecond:", now.microsecond)
print()

d1 = datetime(2018, 6, 13, 4, 55, 27, 8082)  ④
d2 = datetime(2018, 8, 24)

d3 = d2 - d1  ⑤

print("raw time delta:", d3)
print("time delta days:", d3.days)  ⑥

interval = timedelta(10)  ⑦
print("interval:", interval)

d4 = d2 + interval  ⑧
d5 = d2 - interval
print("d2 + interval:", d4)
print("d2 - interval:", d5)
print()

t1 = datetime(2016, 8, 24, 10, 4, 34)  ⑨
```

```
t2 = datetime(2018, 8, 24, 22, 8, 1)
t3 = t2 - t1

print("datetime(2016, 8, 24, 10, 4, 34):", t1)
print("datetime(2018, 8, 24, 22, 8, 1):", t2)
print("time diff (t2 - t1):", t3)
```

datetime_ex.py

```
today: 2021-11-03
type(today): <class 'datetime.date'>
today.month: 11
today.day: 3
today.year: 2021

now: 2021-11-03 10:17:55.243074
now.day: 3
now.month: 11
now.year: 2021
now.hour: 10
now.minute: 17
now.second: 55
now.microsecond: 243074

raw time delta: 71 days, 19:04:32.991918
time delta days: 71
interval: 10 days, 0:00:00
d2 + interval: 2018-09-03 00:00:00
d2 - interval: 2018-08-14 00:00:00

datetime(2016, 8, 24, 10, 4, 34): 2016-08-24 10:04:34
datetime(2018, 8, 24, 22, 8, 1): 2018-08-24 22:08:01
time diff (t2 - t1): 730 days, 12:03:27
```

Zipped archives

- import zipfile for (PK)zipped files
- Get a list of files
- Extract files

The zipfile module allows you to read and write to zipped archives. In either case you first create a zipfile object; specifying a mode of "w" if you want to create an archive, and a mode of "r" (or nothing) if you want to read an existing zip file.

There are also modules for gzipped, bzipped, and compressed archives.

Example

zipfile_ex.py

```
#!/usr/bin/env python

from zipfile import ZipFile, ZIP_DEFLATED
import os.path

# reading & extracting
rzip = ZipFile("../DATA/textfiles.zip")  ①
print(rzip.namelist())  ②
ty = rzip.read('tyger.txt').decode()  ③
print(ty[:50])
rzip.extract('parrot.txt')  ④

# creating a zip file
wzip = ZipFile("example.zip", mode="w", compression=ZIP_DEFLATED)  ⑤
for base in "parrot tyger knights alice poe_sonnet spam".split():
    filename = os.path.join("../DATA", base + '.txt')
    print("adding {} as {}".format(filename, base + '.txt'))
    wzip.write(filename, base + '.txt')  ⑥
```

① Open zip file for reading

② Print list of members in zip file

③ Read (raw binary) data from member and convert from bytes to string

④ Extract member

⑤ Create new zip file

⑥ Add member to zip file

zipfile_ex.py

```
['fruit.txt', 'parrot.txt', 'tyger.txt', 'spam.txt']
           The Tyger

Tyger! Tyger! burning bright
adding ../DATA/parrot.txt as parrot.txt
adding ../DATA/tyger.txt as tyger.txt
adding ../DATA/knights.txt as knights.txt
adding ../DATA/alice.txt as alice.txt
adding ../DATA/poe_sonnet.txt as poe_sonnet.txt
adding ../DATA/spam.txt as spam.txt
```

Chapter 10 Exercises

Exercise 10-1 (print_sys_info.py)

Use the module os to print out the pathname separator, the PATH variable separator, and the extension separator for your OS.

Exercise 10-2 (file_size.py)

Write a script that accepts one or more files on the command line, and prints out the size, one file per line. If any argument is not a file, print out an error message.

TIP	You will need the os.path module.

Appendix A: Where do I go from here?

Resources for learning Python

These are from Jessica Garson, who, among other things, teaches Python classes at NYU. (Used with permission).

Run the script **where_do_i_go.py** to display a web page with live links.

Resources for Learning Python [https://dev.to/jessicagarson/resources-for-learning-python-hd6]

Just getting started

Here are some resources that can help you get started learning how to code.

- Code Newbie Podcast [https://www.codenewbie.org/podcast]
- Dive into Python3 [http://www.diveintopython3.net]
- Learn Python the Hard Way [https://learnpythonthehardway.org/python3]
- Learn Python the Hard Way [https://learnpythonthehardway.org/python3]
- Automate the Boring Stuff with Python [https://automatetheboringstuff.com]
- Automate the Boring Stuff with Python [https://automatetheboringstuff.com]

So you want to be a data scientist?

- Data Wrangling with Python [https://www.amazon.com/Data-Wrangling-Python-Tools-Easier/dp/1491948817]
- Data Analysis in Python [http://www.data-analysis-in-python.org/index.html]
- Titanic: Machine Learning from Disaster [https://www.kaggle.com/c/titanic/discussion/5105]
- Deep Learning with Python [https://www.manning.com/books/deep-learning-with-python]
- How to do X with Python [https://chrisalbon.com/]
- Machine Learning: A Probabilistic Prospective [https://www.amazon.com/Machine-Learning-Probabilistic-Perspective-Computation/dp/0262018020]

So you want to write code for the web?

- Learn flask, some great resources are listed here [https://www.fullstackpython.com/flask.html]
- Django Polls Tutorial [https://docs.djangoproject.com/en/2.0/intro/tutorial01/]
- Hello Web App [https://www.amazon.com/Hello-Web-App-Learn-Build-ebook/dp/B00U5MMZ2E/ref=sr_1_1?ie=UTF8&qid=1510599119&sr=8-1&keywords=hello+web+app]
- Hello Web App Intermediate [https://www.amazon.com/Hello-Web-App-Intermediate-Concepts/dp/0986365920]

- Test-Driven-Development for Web Programming [https://www.obeythetestinggoat.com/pages/book.html#toc]
- 2 Scoops of Django [https://www.amazon.com/Two-Scoops-Django-1-11-Practices-ebook/dp/B076D5FKFX/ref=sr_1_1?s=books&ie=UTF8&qid=1510598897&sr=1-1&keywords=2+scoops+of+django]
- HTML and CSS: Design and Build Websites [https://www.amazon.com/HTML-CSS-Design-Build-Websites/dp/1118008189/ref=sr_1_1?ie=UTF8&qid=1510599157&sr=8-1&keywords=css+and+html]
- JavaScript and JQuery [https://www.amazon.com/JavaScript-JQuery-Interactive-Front-End-Development/dp/1118531647]

Not sure yet, that's okay!

Here are some resources for self guided learning. I recommend trying to be very good at Python and the rest should figure itself out in time.

- Python 3 Crash Course [https://www.amazon.com/Python-Crash-Course-Hands-Project-Based/dp/1593276036]
- Base CS Podcast [https://www.codenewbie.org/basecs]
- Writing Idiomatic Python [https://www.amazon.com/Writing-Idiomatic-Python-Jeff-Knupp-ebook/dp/B00B5VXMRG]
- Fluent Python [https://www.amazon.com/dp/1491946008?aaxitk=o7.Y1C9z7oJp87fs3ev30Q&pd_rd_i=1491946008&hsa_cr_id=1406361870001]
- Pro Python [https://www.amazon.com/Pro-Python-Marty-Alchin/dp/1484203356/ref=sr_1_1?s=books&ie=UTF8&qid=1510598874&sr=1-1&keywords=pro+python]
- Refactoring [https://www.amazon.com/Refactoring-Improving-Design-Existing-Code/dp/0201485672/ref=sr_1_1?ie=UTF8&qid=1510598784&sr=8-1&keywords=refactoring+martin+fowler]
- Clean Code [https://www.amazon.com/Clean-Code-Handbook-Software-Craftsmanship/dp/0132350882/ref=sr_1_1?s=books&ie=UTF8&qid=1510598926&sr=1-1&keywords=clean+code]
- Write music with Python, since that's my favorite way to learn a new language [https://github.com/reckoner165/soundmodular]

Appendix B: Python Bibliography

Title	Author	Publisher
Data Science		
Building machine learning systems with Python	William Richert, Luis Pedro Coelho	Packt Publishing
High Performance Python	Mischa Gorlelick and Ian Ozsvald	O'Reilly Media
Introduction to Machine Learning with Python	Sarah Guido	O'Reilly & Assoc.
iPython Interactive Computing and Visualization Cookbook	Cyril Rossant	Packt Publishing
Learning iPython for Interactive Computing and Visualization	Cyril Rossant	Packt Publishing
Learning Pandas	Michael Heydt	Packt Publishing
Learning scikit-learn: Machine Learning in Python	Raúl Garreta, Guillermo Moncecchi	Packt Publishing
Mastering Machine Learning with Scikit-learn	Gavin Hackeling	Packt Publishing
Matplotlib for Python Developers	Sandro Tosi	Packt Publishing
Numpy Beginner's Guide	Ivan Idris	Packt Publishing
Numpy Cookbook	Ivan Idris	Packt Publishing
Practical Data Science Cookbook	Tony Ojeda, Sean Patrick Murphy, Benjamin Bengfort, Abhijit Dasgupta	Packt Publishing
Python Text Processing with NLTK 2.0 Cookbook	Jacob Perkins	Packt Publishing
Scikit-learn cookbook	Trent Hauck	Packt Publishing
Python Data Visualization Cookbook	Igor Milovanovic	Packt Publishing
Python for Data Analysis	Wes McKinney	O'Reilly & Assoc.
Design Patterns		
Design Patterns: Elements of Reusable Object-Oriented Software	Erich Gamma, Richard Helm, Ralph Johnson, John Vlissides	Addison-Wesley Professional

Title	Author	Publisher
Head First Design Patterns	Eric Freeman, Elisabeth Robson, Bert Bates, Kathy Sierra	O'Reilly Media
Learning Python Design Patterns	Gennadiy Zlobin	Packt Publishing
Mastering Python Design Patterns	Sakis Kasampalis	Packt Publishing
General Python development		
Expert Python Programming	Tarek Ziadé	Packt Publishing
Fluent Python	Luciano Ramalho	O'Reilly & Assoc.
Learning Python, 2nd Ed.	Mark Lutz, David Asher	O'Reilly & Assoc.
Mastering Object-oriented Python	Stephen F. Lott	Packt Publishing
Programming Python, 2nd Ed.	Mark Lutz	O'Reilly & Assoc.
Python 3 Object Oriented Programming	Dusty Phillips	Packt Publishing
Python Cookbook, 3nd. Ed.	David Beazley, Brian K. Jones	O'Reilly & Assoc.
Python Essential Reference, 4th. Ed.	David M. Beazley	Addison-Wesley Professional
Python in a Nutshell	Alex Martelli	O'Reilly & Assoc.
Python Programming on Win32	Mark Hammond, Andy Robinson	O'Reilly & Assoc.
The Python Standard Library By Example	Doug Hellmann	Addison-Wesley Professional
Misc		
Python Geospatial Development	Erik Westra	Packt Publishing
Python High Performance Programming	Gabriele Lanaro	Packt Publishing
Networking		
Python Network Programming Cookbook	Dr. M. O. Faruque Sarker	Packt Publishing
Violent Python: A Cookbook for Hackers, Forensic Analysts, Penetration Testers and Security Engineers	T J O'Connor	Syngress
Web Scraping with Python	Ryan Mitchell	O'Reilly & Assoc.
Testing		

Title	Author	Publisher
Python Testing Cookbook	Greg L. Turnquist	Packt Publishing
Learning Python Testing	Daniel Arbuckle	Packt Publishing
Learning Selenium Testing Tools, 3rd Ed.	Raghavendra Prasad MG	Packt Publishing
Web Development		
Building Web Applications with Flask	Italo Maia	Packt Publishing
Django 1.0 Website Development	Ayman Hourieh	Packt Publishing
Django 1.1 Testing and Development	Karen M. Tracey	Packt Publishing
Django By Example	Antonio Melé	Packt Publishing
Django Design Patterns and Best Practices	Arun Ravindran	Packt Publishing
Django Essentials	Samuel Dauzon	Packt Publishing
Django Project Blueprints	Asad Jibran Ahmed	Packt Publishing
Flask Blueprints	Joel Perras	Packt Publishing
Flask by Example	Gareth Dwyer	Packt Publishing
Flask Framework Cookbook	Shalabh Aggarwal	Packt Publishing
Flask Web Development	Miguel Grinberg	O'Reilly & Assoc.
Full Stack Python (e-book only)	Matt Makai	Gumroad (or free download)
Full Stack Python Guide to Deployments (e-book only)	Matt Makai	Gumroad (or free download)
High Performance Django	Peter Baumgartner, Yann Malet	Lincoln Loop
Instant Flask Web Development	Ron DuPlain	Packt Publishing
Learning Flask Framework	Matt Copperwaite, Charles O Leifer	Packt Publishing
Mastering Flask	Jack Stouffer	Packt Publishing
Two Scoops of Django: Best Practices for Django 1.11	Daniel Roy Greenfeld, Audrey Roy Greenfeld	Two Scoops Press
Web Development with Django Cookbook	Aidas Bendoraitis	Packt Publishing

Appendix C: String Formatting

Overview

- Strings have a format() method
- Allows values to be inserted in strings
- Values can be formatted
- Add a field as placeholders for variable
- Field syntax: `{SELECTOR:FORMATTING}`
- Selector can be index or keyword
- Formatting controls alignment, width, padding, etc.

Python provides a powerful and flexible way to format data. The string method format() takes one or more parameters, which are inserted into the string via placeholders.

The placeholders, called fields, consist of a pair of braces enclosing parameter selectors and formatting directives.

The selector can be followed by a set of formatting directives, which always start with a colon. The simplest directives specify the type of variable to be formatted. For instance, {1:d} says to format the second parameter as an integer; {0:.2f} says to format the first parameter as a float, rounded to two decimal points.

The formatting part can consist of the following components, which will be explained in detail in the following pages:

```
:[[fill]align][sign][#][0][width][,][.precision][type]
```

Parameter Selectors

- Null for auto-numbering
- Can be numbers or keywords
- Start at 0 for numbers

Selectors refer to which parameter will be used in a placeholder.

Null (empty) selectors — the most common — will be treated as though they were filled in with numbers from left to right, beginning with 0. Null selectors cannot be mixed with numbered or named selectors — either all of the selectors or none of the selectors must be null.

Non-null selectors can be either numeric indices or keywords (strings). Thus, {0} will be replaced with the first parameter, {4} will be replaced with the fifth parameter, and so on. If using keywords, then {name} will be replaced by the value of keyword 'name', and {age} will be replaced by keyword 'age'.

Parameters do not have to be in the same order in which they occur in the string, although they typically are. The same parameter can be used in multiple fields.

If positional and keyword parameters are both used, the keyword parameters must come after all positional parameters.

Example

fmt_params.py

```
#!/usr/bin/env python

person = 'Bob'
age = 22

print("{0} is {1} years old.".format(person, age))  ①
print("{0}, {0}, {0} your boat".format('row'))  ②
print("The {1}-year-old is {0}".format(person, age))  ③
print("{name} is {age} years old.".format(name=person, age=age))  ④
print()
print("{} is {} years old.".format(person, age))  ⑤
print("{name} is {} and his favorite color is {}".format(22, 'blue', name='Bob'))  ⑥
```

① Placeholders can be numbered

② Placeholders can be reused

③ They do not have to be in order (but usually are)

④ Selectors can be named

⑤ Empty selectors are autonumbered (but all selectors must either be empty or explicitly numbered)

⑥ Named and numbered selectors can be mixed

fmt_params.py

```
Bob is 22 years old.
row, row, row your boat
The 22-year-old is Bob
Bob is 22 years old.

Bob is 22 years old.
Bob is 22 and his favorite color is blue
```

f-strings

- **f** in front of literal strings
- More readable
- Same rules as `string.format()`

Starting with version 3.6, Python also supports *f-strings*.

The big difference from the `format()` method is that the parameters are inside the `{}` placeholders. Place formatting details after a `:` as usual.

Since the parameters are part of the placeholders, parameter numbers are not used.

All of the following formatting tools work with both `string.format()` and f-strings.

Example

fmt_fstrings.py

```
#!/usr/bin/env python

person = 'Bob'
age = 22

print(f"{person} is {age} years old.")
print(f"The {age}-year-old is {person}.")
print()
```

fmt_fstrings.py

```
Bob is 22 years old.
The 22-year-old is Bob.
```

Data types

- Fields can specify data type
- Controls formatting
- Raises error for invalid types

The type part of the format directive tells the formatter how to convert the value. Builtin types have default formats – 's' for strings, 'd' for integers, 'f' for float.

Some data types can be specified as either upper or lower case. This controls the output of letters. E.g, {:x} would format the number 48879 as 'beef', but {:X} would format it as 'BEEF'.

The type must generally match the type of the parameter. An integer cannot be formatted with type 's'. Integers can be formatted as floats, but not the other way around. Only integers may be formatted as binary, octal, or hexadecimal.

Example

fmt_types.py

```
#!/usr/bin/env python

person = 'Bob'
value = 488
bigvalue = 3735928559
result = 234.5617282027

print('{:s}'.format(person))    ①
print('{name:s}'.format(name=person))    ②
print('{:d}'.format(value))    ③
print('{:b}'.format(value))    ④
print('{:o}'.format(value))    ⑤
print('{:x}'.format(value))    ⑥
print('{:X}'.format(bigvalue))    ⑦
print('{:f}'.format(result))    ⑧
print('{:.2f}'.format(result))    ⑨
```

① String

② String

③ Integer (displayed as decimal)

④ Integer (displayed as binary)

⑤ Integer (displayed as octal)

⑥ Integer (displayed as hex)

⑦ Integer (displayed as hex with uppercase digits)

⑧ Float (defaults to 6 places after the decimal point)

⑨ Float rounded to 2 decimal places

fmt_types.py

```
Bob
Bob
488
111101000
750
1e8
DEADBEEF
234.561728
234.56
```

Table 15. Formatting Types

b	Binary – converts number to base 2
c	Character – converts to corresponding character, like chr()
d	Decimal – outputs number in base 10
e, E	Exponent notation. 'e' prints the number in scientific notation using the letter 'e' to indicate the exponent. 'E' is the same, except it uses the letter 'E'
f,F	Floating point. 'F' and 'f' are the same.
g	General format. For a given precision p >= 1, rounds the number to p significant digits and then formats the result in fixed-point or scientific notation, depending on magnitude. This is the default for numbers
G	Same as g, but upper-cases 'e', 'nan', and 'inf"
n	Same as d, but uses locale setting for number separators
o	Octal – converts number to base 8
s	String format. This is the default type for strings
x, X	Hexadecimal – convert number to base 16; A-F match case of 'x' or 'X'
%	Percentage. Multiplies the number by 100 and displays in fixed ('f') format, followed by a percent sign.

Field Widths

- Specified as {0:width.precision}
- Width is really minimum width
- Precision is either maximum width or # decimal points

Fields can specify a minimum width by putting a number before the type. If the parameter is shorted than the field, it will be padded with spaces, on the left for numbers, and on the right for strings.

The precision is specified by a period followed by an integer. For strings, precision means the maximum width. Strings longer than the maximum will be truncated. For floating point numbers, precision means the number of decimal places displayed, which will be padded with zeros as needed.

Width and precision are both optional. The default width for all fields is 0; the default precision for floating point numbers is 6.

It is invalid to specify precision for an integer.

Example

fmt_width.py

```
#!/usr/bin/env python

name = 'Ann Elk'
value = 10000
airspeed = 22.347
# note: [] are used to show blank space, and are not part of the formatting
print('[{:s}]'.format(name))     ①
print('[{:10s}]'.format(name))   ②
print('[{:3s}]'.format(name))    ③
print('[{:3.3s}]'.format(name))  ④
print()
print('[{:8d}]'.format(value))       ⑤
print('[{:8f}]'.format(value))       ⑥
print('[{:8f}]'.format(airspeed))    ⑦
print('[{:.2f}]'.format(airspeed))   ⑧
print('[{:8.3f}]'.format(airspeed))  ⑨
```

① Default format — no padding

② Left justify, 10 characters wide

③ Left justify, 3 characters wide, displays entire string

④ Left justify, 3 characters wide, truncates string to max width

⑤ Right justify, decimal, 8 characters wide (all numbers are right-justified by default)

⑥ Right justify int as float, 8 characters wide

⑦ Right justify float as float, 8 characters wide

⑧ Right justify, float, 3 decimal places, no maximum width

⑨ Right justify, float, 3 decimal places, maximum width 8

fmt_width.py

```
[Ann Elk]
[Ann Elk   ]
[Ann Elk]
[Ann]

[   10000]
[10000.000000]
[22.347000]
[22.35]
[  22.347]
```

Alignment

- Alignment within field can be left, right, or centered
  - < left align
  - > right align
  - ^ center
  - = right align but put padding after sign

You can align the data to be formatted. It can be left-aligned (the default), right-aligned, or centered. If formatting signed numbers, the minus sign can be placed on the left side.

Example

fmt_align.py

```
#!/usr/bin/env python

name = 'Ann'
value = 12345
nvalue = -12345

①
print('[{0:10s}]'.format(name))    ②
print('[{0:<10s}]'.format(name))   ③
print('[{0:>10s}]'.format(name))   ④
print('[{0:^10s}]'.format(name))   ⑤
print()
print('[{0:10d}] [{1:10d}]'.format(value, nvalue))    ⑥
print('[{0:>10d}] [{1:>10d}]'.format(value, nvalue))  ⑦
print('[{0:<10d}] [{1:<10d}]'.format(value, nvalue))  ⑧
print('[{0:^10d}] [{1:^10d}]'.format(value, nvalue))  ⑨
print('[{0:=10d}] [{1:=10d}]'.format(value, nvalue))  ⑩
```

① note: all of the following print in a field 10 characters widedd

② Default (left) alignment

③ Explicit left alignment

④ Right alignment

⑤ Centered

⑥ Default (right) alignment

⑦ Explicit right alignment

⑧ Left alignment

⑨ Centered

⑩ Right alignment, but pad *after* sign

fmt_align.py

```
[Ann        ]
[Ann        ]
[        Ann]
[   Ann     ]

[     12345] [    -12345]
[     12345] [    -12345]
[12345     ] [-12345    ]
[  12345   ] [  -12345  ]
[     12345] [-    12345]
```

Fill characters

- Padding character must precede alignment character
- Default is one space
- Can be any character except }

By default, if a field width is specified and the data does not fill the field, it is padded with spaces. A character preceding the alignment character will be used as the fill character.

Example

fmt_fill.py

```
#!/usr/bin/env python

name = 'Ann'
value = 123

print('[{:>10s}]'.format(name))    ①
print('[{:.>10s}]'.format(name))   ②
print('[{:->10s}]'.format(name))    ③
print('[{:.10s}]'.format(name))    ④
print()
print('[{:10d}]'.format(value))    ⑤
print('[{:010d}]'.format(value))   ⑥
print('[{:_>10d}]'.format(value))  ⑦
print('[{:+>10d}]'.format(value))  ⑧
```

① Right justify string, pad with space (default)

② Right justify string, pad with '.'

③ Right justify string, pad with '-'

④ Left justify string, pad with '.'

⑤ Right justify number, pad with space (default

⑥ Right justify number, pad with zeroes

⑦ Right justfy, pad with '_' ('>' required)

⑧ Right justfy, pad with '+' ('>' required)

fmt_fill.py

```
[       Ann]
[.......Ann]
[-------Ann]
[Ann]

[       123]
[0000000123]
[_______123]
[+++++++123]
```

Signed numbers

- Can pad with any character except '{}'
- Sign can be '+', '-', or space
- Only appropriate for numeric types

The sign character follows the alignment character, and can be plus, minus, or space.

A plus sign means always display + or – preceding non-zero numbers.

A minus sign means only display a sign for negative numbers.

A space means display a – for negative numbers and a space for positive numbers.

Example

fmt_signed.py

```
#!/usr/bin/env python

values = 123, -321, 14, -2, 0

for value in values:
    print("default: |{:d}|".format(value))  ①
print()

for value in values:
    print("   plus: |{:+d}|".format(value))  ②
print()

for value in values:
    print("  minus: |{:-d}|".format(value)) ③
print()

for value in values:
    print("  space: |{: d}|".format(value)) ④
print()
```

① default (pipe symbols just to show white space)

② plus sign puts '+' on positive numbers (and zero) and '-' on negative

③ minus sign only puts '-' on negative numbers

④ space puts '-' on negative numbers and space on others

fmt_signed.py

```
default: |123|
default: |-321|
default: |14|
default: |-2|
default: |0|

   plus: |+123|
   plus: |-321|
   plus: |+14|
   plus: |-2|
   plus: |+0|

  minus: |123|
  minus: |-321|
  minus: |14|
  minus: |-2|
  minus: |0|

  space: | 123|
  space: |-321|
  space: | 14|
  space: |-2|
  space: | 0|
```

Parameter Attributes

- Specify elements or properties in template
- No need to repeat parameters
- Works with sequences, mappings, and objects

When specifying container variables as parameters, you can select elements in the format rather than in the parameter list. For sequences or dictionaries, index on the selector with []. For object attributes, access the attribute from the selector with . (period).

Example

fmt_attrib.py

```
#!/usr/bin/env python

from datetime import date

fruits = 'apple', 'banana', 'mango'
values = [5, 18, 27, 6]
dday = date(1944, 6, 6)
pythons = {'Idle': 'Eric', 'Cleese': 'John', 'Gilliam': 'Terry',
           'Chapman': 'Graham', 'Palin': 'Michael', 'Jones': 'Terry'}

print('{0[0]} {0[2]}'.format(fruits))  ①
print('{f[0]} {f[2]}'.format(f=fruits))  ②
print()
print('{0[0]} {0[2]}'.format(values))  ③
print()
print('{0[Palin]} {0[Cleese]}'.format(pythons))  ④
print('{names[Palin]} {names[Cleese]}'.format(names=pythons))  ⑤
print()
print('{0.month}-{0.day}-{0.year}'.format(dday))  ⑥
```

① select from tuple

② named parameter + select from tuple

③ Select from list

④ select from dict

⑤ named parameter + select from dict

⑥ select attributes from date

fmt_attrib.py

```
apple mango
apple mango

5 27

Michael John
Michael John

6-6-1944
```

Formatting Dates

- Special formats for dates
- Pull appropriate values from date/time objects

To format dates, use special date formats. These are placed, like all formatting codes, after a colon. For instance, {0:%B %d, %Y} will format a parameter (which must be a datetime.datetime or datetime.date) as "Month DD, YYYY".

Example

fmt_dates.py

```
#!/usr/bin/env python

from datetime import datetime

event = datetime(2016, 1, 2, 3, 4, 5)

print(event)  ①
print()

print("Date is {0:%m}/{0:%d}/{0:%y}".format(event))  ②
print("Date is {:%m/%d/%y}".format(event))  ③
print("Date is {:%A, %B %d, %Y}".format(event))  ④
```

① Default string version of date

② Use three placeholders for month, day, year

③ Format month, day, year with a single placeholder

④ Another single placeholder format

fmt_dates.py

```
2016-01-02 03:04:05

Date is 01/02/16
Date is 01/02/16
Date is Saturday, January 02, 2016
```

Table 16. Date Formats

Directive	Meaning	See note
%a	Locale's abbreviated weekday name.	
%A	Locale's full weekday name.	
%b	Locale's abbreviated month name.	
%B	Locale's full month name.	
%c	Locale's appropriate date and time representation.	
%d	Day of the month as a decimal number [01,31].	
%f	Microsecond as a decimal number [0,999999], zero-padded on the left	1
%H	Hour (24-hour clock) as a decimal number [00,23].	
%I	Hour (12-hour clock) as a decimal number [01,12].	
%j	Day of the year as a decimal number [001,366].	
%m	Month as a decimal number [01,12].	
%M	Minute as a decimal number [00,59].	
%p	Locale's equivalent of either AM or PM.	2
%S	Second as a decimal number [00,61].	3
%U	Week number of the year (Sunday as the first day of the week) as a decimal number [00,53]. All days in a new year preceding the first Sunday are considered to be in week 0.	4
%w	Weekday as a decimal number [0(Sunday),6].	
%W	Week number of the year (Monday as the first day of the week) as a decimal number [00,53]. All days in a new year preceding the first Monday are considered to be in week 0.	4
%x	Locale's appropriate date representation.	
%X	Locale's appropriate time representation.	
%y	Year without century as a decimal number [00,99].	
%Y	Year with century as a decimal number.	
%z	UTC offset in the form +HHMM or -HHMM (empty string if the the object is naive).	5
%Z	Time zone name (empty string if the object is naive).	
%%	A literal '%' character.	

1. When used with the strptime() method, the %f directive accepts from one to six digits and zero pads on the right. %f is an extension to the set of format characters in the C standard (but

implemented separately in datetime objects, and therefore always available).

2. When used with the strptime() method, the %p directive only affects the output hour field if the %I directive is used to parse the hour.
3. The range really is 0 to 61; according to the Posix standard this accounts for leap seconds and the (very rare) double leap seconds. The time module may produce and does accept leap seconds since it is based on the Posix standard, but the datetime module does not accept leap seconds instrptime() input nor will it produce them in strftime() output.
4. When used with the strptime() method, %U and %W are only used in calculations when the day of the week and the year are specified.
5. For example, if utcoffset() returns timedelta(hours=-3, minutes=-30), %z is replaced with the string '-0330'.

Run-time formatting

- Use parameters to specify alignment, precision, width, and type
- Use {} placeholders for runtime values for the above

To specify formatting values at runtime, use a {} placeholder for the value, and insert the desired value in the parameter list. These placeholders are numbered along with the normal placeholders.

Example

fmt_runtime.py

```
#!/usr/bin/env python

FIRST_NAME = 'Fred'
LAST_NAME = 'Flintstone'
AGE = 35

print("{0} {1}".format(FIRST_NAME, LAST_NAME))

WIDTH = 12
print("{0:{width}s} {1:{width}s}".format(  ①
    FIRST_NAME,
    LAST_NAME,
    width=WIDTH,
))

PAD = '-'
WIDTH = 20
ALIGNMENTS = ('<', '>', '^')

for alignment in ALIGNMENTS:
    print("{0:{pad}{align}{width}s} {1:{pad}{align}{width}s}".format(  ②
        FIRST_NAME,
        LAST_NAME,
        width=WIDTH,
        pad=PAD,
        align=alignment,
    ))
```

① value of WIDTH used in format spec

② values of PAD, WIDTH, ALIGNMENTS used in format spec

fmt_runtime.py

```
Fred Flintstone
Fred         Flintstone
Fred---------------- Flintstone----------
----------------Fred ----------Flintstone
--------Fred-------- -----Flintstone-----
```

Miscellaneous tips and tricks

- Adding commas to large numbers {n:,}
- Auto-converting parameters to strings (!s)
- Non-decimal prefixes

- Adding commas to large numbers {n:,}

You can add a comma to the format to add commas to numbers greater than 999.

Using a format type of !s will call str() on the parameter and force it to be a string.

Using a # (pound sign) will cause binary, octal, or hex output to be preceded by '0b', '0o', or '0x'. This is only valid with type codes b, o, and x.

Example

fmt_misc.py

```
#!/usr/bin/env python

'''Demonstrate misc formatting'''

big_number = 2303902390239

print("Big number: {:,d}".format(big_number))  ①
print()

value = 27

print("Binary: {:#010b}".format(value))  ②
print("Octal:  {:#010o}".format(value))  ③
print("Hex:    {:#010x}".format(value))  ④
print()
```

① Add commas for readability

② Binary format with leading 0b

③ Octal format with leading 0o

④ Hexadecimal format with leading 0x

fmt_misc.py

```
Big number: 2,303,902,390,239

Binary: 0b00011011
Octal:  0o00000033
Hex:    0x0000001b
```

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