Ch12-Modules-Packages

September 10, 2025

1 Modules and Packages

http://openbookproject.net/thinkcs/python/english3e/modules.html - module is a file containing Python definitions and statements intended for use in other Python programs - standard library is an example of Python language provided modules

1.1 Various ways to import names into the current namespace

[1]:
```
# import math module into the global namespace
import math
x = math.sqrt(100)
print(x)
```

```
10.0
```

[2]:
```
import random
print(random.choice(list(range(1, 21))))
```

```
20
```

[3]:
```
from random import choice
```

[4]:
```
print(choice([1, 2, 3, 4]))
```

```
2
```

[5]:
```
help(math)
```

```
Help on module math:

NAME
    math

MODULE REFERENCE
    https://docs.python.org/3.8/library/math

    The following documentation is automatically generated from the Python
    source files.  It may be incomplete, incorrect or include features that
    are considered implementation detail and may vary between Python
    implementations.  When in doubt, consult the module reference at the
```

```
    location listed above.

DESCRIPTION
    This module provides access to the mathematical functions
    defined by the C standard.

FUNCTIONS
    acos(x, /)
        Return the arc cosine (measured in radians) of x.

    acosh(x, /)
        Return the inverse hyperbolic cosine of x.

    asin(x, /)
        Return the arc sine (measured in radians) of x.

    asinh(x, /)
        Return the inverse hyperbolic sine of x.

    atan(x, /)
        Return the arc tangent (measured in radians) of x.

    atan2(y, x, /)
        Return the arc tangent (measured in radians) of y/x.

        Unlike atan(y/x), the signs of both x and y are considered.

    atanh(x, /)
        Return the inverse hyperbolic tangent of x.

    ceil(x, /)
        Return the ceiling of x as an Integral.

        This is the smallest integer >= x.

    comb(n, k, /)
        Number of ways to choose k items from n items without repetition and
without order.

        Evaluates to n! / (k! * (n - k)!) when k <= n and evaluates
        to zero when k > n.

        Also called the binomial coefficient because it is equivalent
        to the coefficient of k-th term in polynomial expansion of the
        expression (1 + x)**n.

        Raises TypeError if either of the arguments are not integers.
        Raises ValueError if either of the arguments are negative.
```

```
    copysign(x, y, /)
        Return a float with the magnitude (absolute value) of x but the sign of
y.

        On platforms that support signed zeros, copysign(1.0, -0.0)
        returns -1.0.

    cos(x, /)
        Return the cosine of x (measured in radians).

    cosh(x, /)
        Return the hyperbolic cosine of x.

    degrees(x, /)
        Convert angle x from radians to degrees.

    dist(p, q, /)
        Return the Euclidean distance between two points p and q.

        The points should be specified as sequences (or iterables) of
        coordinates.  Both inputs must have the same dimension.

        Roughly equivalent to:
            sqrt(sum((px - qx) ** 2.0 for px, qx in zip(p, q)))

    erf(x, /)
        Error function at x.

    erfc(x, /)
        Complementary error function at x.

    exp(x, /)
        Return e raised to the power of x.

    expm1(x, /)
        Return exp(x)-1.

        This function avoids the loss of precision involved in the direct
evaluation of exp(x)-1 for small x.

    fabs(x, /)
        Return the absolute value of the float x.

    factorial(x, /)
        Find x!.

        Raise a ValueError if x is negative or non-integral.
```

```
floor(x, /)
    Return the floor of x as an Integral.

    This is the largest integer <= x.

fmod(x, y, /)
    Return fmod(x, y), according to platform C.

    x % y may differ.

frexp(x, /)
    Return the mantissa and exponent of x, as pair (m, e).

    m is a float and e is an int, such that x = m * 2.**e.
    If x is 0, m and e are both 0.  Else 0.5 <= abs(m) < 1.0.

fsum(seq, /)
    Return an accurate floating point sum of values in the iterable seq.

    Assumes IEEE-754 floating point arithmetic.

gamma(x, /)
    Gamma function at x.

gcd(x, y, /)
    greatest common divisor of x and y

hypot(…)
    hypot(*coordinates) -> value

    Multidimensional Euclidean distance from the origin to a point.

    Roughly equivalent to:
        sqrt(sum(x**2 for x in coordinates))

    For a two dimensional point (x, y), gives the hypotenuse
    using the Pythagorean theorem:  sqrt(x*x + y*y).

    For example, the hypotenuse of a 3/4/5 right triangle is:

        >>> hypot(3.0, 4.0)
        5.0

isclose(a, b, *, rel_tol=1e-09, abs_tol=0.0)
    Determine whether two floating point numbers are close in value.

      rel_tol
```

```
            maximum difference for being considered "close", relative to the
            magnitude of the input values
          abs_tol
            maximum difference for being considered "close", regardless of the
            magnitude of the input values

        Return True if a is close in value to b, and False otherwise.

        For the values to be considered close, the difference between them
        must be smaller than at least one of the tolerances.

        -inf, inf and NaN behave similarly to the IEEE 754 Standard.  That
        is, NaN is not close to anything, even itself.  inf and -inf are
        only close to themselves.

    isfinite(x, /)
        Return True if x is neither an infinity nor a NaN, and False otherwise.

    isinf(x, /)
        Return True if x is a positive or negative infinity, and False
otherwise.

    isnan(x, /)
        Return True if x is a NaN (not a number), and False otherwise.

    isqrt(n, /)
        Return the integer part of the square root of the input.

    ldexp(x, i, /)
        Return x * (2**i).

        This is essentially the inverse of frexp().

    lgamma(x, /)
        Natural logarithm of absolute value of Gamma function at x.

    log(…)
        log(x, [base=math.e])
        Return the logarithm of x to the given base.

        If the base not specified, returns the natural logarithm (base e) of x.

    log10(x, /)
        Return the base 10 logarithm of x.

    log1p(x, /)
        Return the natural logarithm of 1+x (base e).
```

```
        The result is computed in a way which is accurate for x near zero.

    log2(x, /)
        Return the base 2 logarithm of x.

    modf(x, /)
        Return the fractional and integer parts of x.

        Both results carry the sign of x and are floats.

    perm(n, k=None, /)
        Number of ways to choose k items from n items without repetition and
with order.

        Evaluates to n! / (n - k)! when k <= n and evaluates
        to zero when k > n.

        If k is not specified or is None, then k defaults to n
        and the function returns n!.

        Raises TypeError if either of the arguments are not integers.
        Raises ValueError if either of the arguments are negative.

    pow(x, y, /)
        Return x**y (x to the power of y).

    prod(iterable, /, *, start=1)
        Calculate the product of all the elements in the input iterable.

        The default start value for the product is 1.

        When the iterable is empty, return the start value.  This function is
        intended specifically for use with numeric values and may reject
        non-numeric types.

    radians(x, /)
        Convert angle x from degrees to radians.

    remainder(x, y, /)
        Difference between x and the closest integer multiple of y.

        Return x - n*y where n*y is the closest integer multiple of y.
        In the case where x is exactly halfway between two multiples of
        y, the nearest even value of n is used. The result is always exact.

    sin(x, /)
        Return the sine of x (measured in radians).
```

```
    sinh(x, /)
        Return the hyperbolic sine of x.

    sqrt(x, /)
        Return the square root of x.

    tan(x, /)
        Return the tangent of x (measured in radians).

    tanh(x, /)
        Return the hyperbolic tangent of x.

    trunc(x, /)
        Truncates the Real x to the nearest Integral toward 0.

        Uses the __trunc__ magic method.

DATA
    e = 2.718281828459045
    inf = inf
    nan = nan
    pi = 3.141592653589793
    tau = 6.283185307179586

FILE
    /Users/rbasnet/miniconda3/lib/python3.8/lib-
dynload/math.cpython-38-darwin.so
```

[6]:
```
from math import * # Import all the identifiers from math
print(sqrt(100))
print(pi)
```

```
10.0
3.141592653589793
```

[7]:
```
from math import radians, sin
rad = radians(90)
print(rad)
print(sin(rad))
```

```
1.5707963267948966
1.0
```

1.2 names can be imported into the local namespace

[8]:
```
def isUpper(letter):
    import string # string name is local
    return letter in string.ascii_uppercase
```

[9]:
```
print(isUpper('a'))
```

```
False
```

[10]:
```
# can we use string module outside isUpper function?
print(string.digits)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-10-1f51304bf154> in <module>
      1 # can we use string module outside isUpper function?
----> 2 print(string.digits)

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

1.3 Variable scopes and lookup rules

- the **scope** of an identifier is the region of program code in which the identifier can be accessed, or used
- three important scopes in Python:
  - `Local scope` - refers to identifiers declared within a function
  - `Global scope` - refers to all the identifiers declared within the current module, or file
  - `Built-in scope` - refers to all the identifiers built into Python – those like *print* and *input* that are always available

1.3.1 Precedence rule for lookup

1. innermost or local scope
2. global scope
3. built-in scope

[9]:
```
def testLocalScope():
    outer = 5
    def innerFunction(): # only available insed testLocalScope
        inner = 10
        print('innerFunction called:')
        print(f'{outer=}')
        print(f'{inner=}')
    # print(f'{inner=}') # inner varaible is ONLY available inside innerFunction
    print(f'{outer=}')
    innerFunction()
```

[10]:
```
testLocalScope()
```

```
outer=5
innerFunction called:
outer=5
inner=10
```

[6]:
```
# this throws NameError!
innerFunction()
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
Cell In[6], line 1
----> 1 innerFunction()

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

[11]:
```
# can't access `outer` outside the testLocalScope function
print(outer)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
Cell In[11], line 2
      1 # can't access `outer` outside the testLocalScope function
----> 2 print(outer)

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

1.4 User-defined modules

- see `modules` folder
- see main.py and module2.py inside modules folder
- demonstrates user defined modules and importance of import guard
- run each module, but main.py depends on module2.py

```
if __name__ == '__main__':
    ...
```

2 Packages

- folder with module(s)
- must define *__init__*.py empty module to initialize as package
- can't import package itself (in a useful way) but only module(s) or identifiers in the modules
- https://docs.python.org/3/tutorial/modules.html#packages

2.1 fibos package

- the folder fibos in this repository is an example of Python package
- take a look inside the packate and observe the files
- see demo script `demos/package_demo.py` that uses fibos package
- the following code snippets demonstrate using user-defined package

[14]:
```
# change current working directory to demos
%cd demos
```

```
/Users/rbasnet/CMU/projects/Python-Fundamentals/demos
```

[15]:
```
import fibos
```

[16]:
```
help(fibos)
```

```
Help on package fibos:

NAME
    fibos

PACKAGE CONTENTS
    fibo

FILE
    /Users/rbasnet/CMU/projects/Python-Fundamentals/demos/fibos/__init__.py
```

[17]:
```
# can't use the imported package to access its modules!
fibos.fibo.fib(10)
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
<ipython-input-17-a690191fd105> in <module>
      1 # can't use the imported package to access its modules!
----> 2 fibos.fibo.fib(10)

AttributeError: module 'fibos' has no attribute 'fibo'
```

[18]:
```
# must import the modules or identifiers defined in the package
import fibos.fibo as f
f.fib(10)
```

```
0 1 1 2 3 5 8 13 21 34
```

[19]:
```
from fibos import fibo
fibo.fib2(10)
```

[19]:
```
[0, 1, 1, 2, 3, 5, 8, 13, 21, 34]
```

[ ]:
```

```