:mod:`cmath` --- Mathematical functions for complex numbers

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```
.. module:: cmath
   :synopsis: Mathematical functions for complex numbers.
```

This module provides access to mathematical functions for complex numbers. The functions in this module accept integers, floating-point numbers or complex numbers as arguments. They will also accept any Python object that has either a :meth:`__complex__` or a :meth:`__float__` method: these methods are used to convert the object to a complex or floating-point number, respectively, and the function is then applied to the result of the conversion.

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System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 9); *backlink*

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Note

On platforms with hardware and system-level support for signed zeros, functions involving branch cuts are continuous on *both* sides of the branch cut: the sign of the zero distinguishes one side of the branch cut from the other. On platforms that do not support signed zeros the continuity is as specified below.

Conversions to and from polar coordinates

A Python complex number `z` is stored internally using *rectangular* or *Cartesian* coordinates. It is completely determined by its *real part* `z.real` and its *imaginary part* `z.imag`. In other words:

```
z == z.real + z.imag*1j
```

Polar coordinates give an alternative way to represent a complex number. In polar coordinates, a complex number *z* is defined by the modulus *r* and the phase angle *phi*. The modulus *r* is the distance from *z* to the origin, while the phase *phi* is the counterclockwise angle, measured in radians, from the positive x-axis to the line segment that joins the origin to *z*.

The following functions can be used to convert from the native rectangular coordinates to polar coordinates and back.

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 45)

Unknown directive type "function".

```
.. function:: phase(x)

   Return the phase of *x* (also known as the *argument* of *x*), as a
   float.  ``phase(x)`` is equivalent to ``math.atan2(x.imag,
   x.real)``.  The result lies in the range [-\ *π*, *π*], and the branch
   cut for this operation lies along the negative real axis,
   continuous from above.  On systems with support for signed zeros
   (which includes most systems in current use), this means that the
   sign of the result is the same as the sign of ``x.imag``, even when
   ``x.imag`` is zero::
```

```
>>> phase(complex(-1.0, 0.0))
3.141592653589793
>>> phase(complex(-1.0, -0.0))
-3.141592653589793
```

Note

The modulus (absolute value) of a complex number *x* can be computed using the built-in :func:`abs` function. There is no separate :mod:`cmath` module function for this operation.

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Unknown directive type "function".

```
.. function:: polar(x)

   Return the representation of *x* in polar coordinates.  Returns a
   pair ``(r, phi)`` where *r* is the modulus of *x* and phi is the
   phase of *x*.  ``polar(x)`` is equivalent to ``(abs(x),
   phase(x))``.
```

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Unknown directive type "function".

```
.. function:: rect(r, phi)

   Return the complex number *x* with polar coordinates *r* and *phi*.
   Equivalent to ``r * (math.cos(phi) + math.sin(phi)*1j)``.
```

Power and logarithmic functions

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst, line 86)

Unknown directive type "function".

```
.. function:: exp(x)

   Return *e* raised to the power *x*, where *e* is the base of natural
   logarithms.
```

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst, line 92)

Unknown directive type "function".

```
.. function:: log(x[, base])
```

```
Returns the logarithm of *x* to the given *base*. If the *base* is not
specified, returns the natural logarithm of *x*. There is one branch cut, from 0
along the negative real axis to -∞, continuous from above.
```

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst, line 99)

Unknown directive type "function".

```
.. function:: log10(x)

   Return the base-10 logarithm of *x*. This has the same branch cut as
   :func:`log`.
```

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst, line 105)

Unknown directive type "function".

```
.. function:: sqrt(x)

   Return the square root of *x*. This has the same branch cut as :func:`log`.
```

Trigonometric functions

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst, line 113)

Unknown directive type "function".

```
.. function:: acos(x)

   Return the arc cosine of *x*. There are two branch cuts: One extends right from
   1 along the real axis to ∞, continuous from below. The other extends left from
   -1 along the real axis to -∞, continuous from above.
```

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst, line 120)

Unknown directive type "function".

```
.. function:: asin(x)

   Return the arc sine of *x*. This has the same branch cuts as :func:`acos`.
```

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst, line 125)

Unknown directive type "function".

```
.. function:: atan(x)

   Return the arc tangent of *x*. There are two branch cuts: One extends from
   ``1j`` along the imaginary axis to ``∞j``, continuous from the right. The
   other extends from ``-1j`` along the imaginary axis to ``-∞j``, continuous
   from the left.
```

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst, line 133)

Unknown directive type "function".

```
.. function:: cos(x)

   Return the cosine of *x*.
```

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 138)

Unknown directive type "function".

```
.. function:: sin(x)

   Return the sine of *x*.
```

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 143)

Unknown directive type "function".

```
.. function:: tan(x)

   Return the tangent of *x*.
```

Hyperbolic functions

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 151)

Unknown directive type "function".

```
.. function:: acosh(x)

   Return the inverse hyperbolic cosine of *x*. There is one branch cut,
   extending left from 1 along the real axis to -∞, continuous from above.
```

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 157)

Unknown directive type "function".

```
.. function:: asinh(x)

   Return the inverse hyperbolic sine of *x*. There are two branch cuts:
   One extends from ``1j`` along the imaginary axis to ``∞j``,
   continuous from the right.  The other extends from ``-1j`` along
   the imaginary axis to ``-∞j``, continuous from the left.
```

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 165)

Unknown directive type "function".

```
.. function:: atanh(x)

   Return the inverse hyperbolic tangent of *x*. There are two branch cuts: One
   extends from ``1`` along the real axis to ``∞``, continuous from below. The
   other extends from ``-1`` along the real axis to ``-∞``, continuous from
   above.
```

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 173)

Unknown directive type "function".

```
.. function:: cosh(x)

   Return the hyperbolic cosine of *x*.
```

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 178)

Unknown directive type "function".

```
.. function:: sinh(x)

   Return the hyperbolic sine of *x*.
```

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 183)

Unknown directive type "function".

```
.. function:: tanh(x)

   Return the hyperbolic tangent of *x*.
```

Classification functions

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 191)

Unknown directive type "function".

```
.. function:: isfinite(x)

   Return ``True`` if both the real and imaginary parts of *x* are finite, and
   ``False`` otherwise.

   .. versionadded:: 3.2
```

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 199)

Unknown directive type "function".

```
.. function:: isinf(x)

   Return ``True`` if either the real or the imaginary part of *x* is an
   infinity, and ``False`` otherwise.
```

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 205)

Unknown directive type "function".

```
.. function:: isnan(x)

   Return ``True`` if either the real or the imaginary part of *x* is a NaN,
   and ``False`` otherwise.
```

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 211)

Unknown directive type "function".

```
.. function:: isclose(a, b, *, rel_tol=1e-09, abs_tol=0.0)
```

```
Return ``True`` if the values *a* and *b* are close to each other and
``False`` otherwise.

Whether or not two values are considered close is determined according to
given absolute and relative tolerances.

*rel_tol* is the relative tolerance -- it is the maximum allowed difference
between *a* and *b*, relative to the larger absolute value of *a* or *b*.
For example, to set a tolerance of 5%, pass ``rel_tol=0.05``.  The default
tolerance is ``1e-09``, which assures that the two values are the same
within about 9 decimal digits.  *rel_tol* must be greater than zero.

*abs_tol* is the minimum absolute tolerance -- useful for comparisons near
zero. *abs_tol* must be at least zero.

If no errors occur, the result will be:
``abs(a-b) <= max(rel_tol * max(abs(a), abs(b)), abs_tol)``.

The IEEE 754 special values of ``NaN``, ``inf``, and ``-inf`` will be
handled according to IEEE rules.  Specifically, ``NaN`` is not considered
close to any other value, including ``NaN``.  ``inf`` and ``-inf`` are only
considered close to themselves.

.. versionadded:: 3.5

.. seealso::

   :pep:`485` -- A function for testing approximate equality
```

Constants

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 246)

Unknown directive type "data".

```
.. data:: pi

   The mathematical constant *π*, as a float.
```

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Unknown directive type "data".

```
.. data:: e

   The mathematical constant *e*, as a float.
```

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 256)

Unknown directive type "data".

```
.. data:: tau

   The mathematical constant *τ*, as a float.

   .. versionadded:: 3.6
```

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Unknown directive type "data".

```
.. data:: inf
```

```
    Floating-point positive infinity. Equivalent to ``float('inf')``.

    .. versionadded:: 3.6
```

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Unknown directive type "data".

```
.. data:: infj

   Complex number with zero real part and positive infinity imaginary
   part. Equivalent to ``complex(0.0, float('inf'))``.

   .. versionadded:: 3.6
```

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main] [Doc] [library]cmath.rst`, line 278)

Unknown directive type "data".

```
.. data:: nan

   A floating-point "not a number" (NaN) value.  Equivalent to
   ``float('nan')``.

   .. versionadded:: 3.6
```

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Unknown directive type "data".

```
.. data:: nanj

   Complex number with zero real part and NaN imaginary part. Equivalent to
   ``complex(0.0, float('nan'))``.

   .. versionadded:: 3.6
```

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main] [Doc] [library]cmath.rst`, line 294)

Unknown directive type "index".

```
.. index:: module: math
```

Note that the selection of functions is similar, but not identical, to that in module :mod:`math`. The reason for having two modules is that some users aren't interested in complex numbers, and perhaps don't even know what they are. They would rather have `math.sqrt(-1)` raise an exception than return a complex number. Also note that the functions defined in :mod:`cmath` always return a complex number, even if the answer can be expressed as a real number (in which case the complex number has an imaginary part of zero).

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A note on branch cuts: They are curves along which the given function fails to be continuous. They are a necessary feature of many complex functions. It is assumed that if you need to compute with complex functions, you will understand about branch cuts. Consult almost any (not too elementary) book on complex variables for enlightenment. For information of the proper choice of branch cuts for numerical purposes, a good reference should be the following:

System Message: ERROR/3 (`D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\[cpython-main][Doc][library]cmath.rst`, line 312)

Unknown directive type "seealso".

```
.. seealso::

   Kahan, W:  Branch cuts for complex elementary functions; or, Much ado about
   nothing's sign bit.  In Iserles, A., and Powell, M. (eds.), The state of the art
   in numerical analysis. Clarendon Press (1987) pp165--211.
```