ArrayFunc

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Introduction

The ArrayFunc module provides high speed array processing functions for use with the standard Python array module. These functions are patterned after the functions in the standard Python Itertools module together with some additional ones from other sources.

The purpose of these functions is to perform mathematical calculations on arrays significantly faster than using native Python.

Important Note for Upgrading to Version 4

Version 4 drops support for the amap, amapi, starmap, starmapi, and acalc functions. These have all been replaced by individual functions which perform the same calculations but in a more direct way.

The reason for this change is that it was not possible to support these functions while also providing a simple and consistent call interface. Now each function has a call interface tailored specifically for how that function works. This also provides for a more natural mix of array and numeric parameters.

This change will now allow more mathematical functions to be added in future without trying to force-fit them into a single call interface.

Version 4 also changes the parameter used to select the type of comparison operation for dropwhile, takewhile, aany, aall, findindex, and findindices. This change has been necessitated by the removal of amap and related functions. These functions however should still work in a compatible manner.

Finally, support for the "bytes" type has been dropped.

Function Summary

The functions fall into several categories.

Filling Arrays

Function	Description
count	Fill an array with evenly spaced values using a start and step values.
cycle	Fill an array with evenly spaced values using a start, stop, and step values, and repeat until the array is filled.
repeat	Fill an array with a specified value.

Filtering Arrays

Function	Description
afilter	Select values from an array based on a boolean criteria.
compress	Select values from an array based on another array of boolean values.
dropwhile	Select values from an array starting from where a selected criteria fails and proceding to the end.
takewhile	Like dropwhile, but starts from the beginning and stops when the criteria fails.

Examining and Searching Arrays

Function	Description
findindex	Returns the index of the first value in an array to meet the specified criteria.
findindices	Searches an array for the array indices which meet the specified criteria and writes the results to a second array. Also returns the number of matches found.

Summarising Arrays

Function	Description
aany	Returns True if any element in an array meets the selected criteria.
aall	Returns True if all element in an array meet the selected criteria.
amax	Returns the maximum value in the array.
amin	Returns the minimum value in the array.
asum	Calculate the arithmetic sum of an array.

Data Conversion

Function	Description
convert	Convert arrays between data types. The data will be converted into the form required by the output array.

Mathematical operator functions

Function	Equivalent to
add	x + y
truediv	x / y
floordiv	x // y
mod	x % y
mul	x * y
neg	-x
pow	x**y or math.pow(x, y)
sub	x - y
abs_	abs(x)

Comparison operator functions

Function	Equivalent to
eq	x == y
gt	x > y
ge	x >= y

lt	x < y
le	x <= y
ne	x != y

Bitwise operator functions

Function	Equivalent to
and_	x & y
or_	x | y
xor	x ^ y
invert	~x
lshift	x << y
rshift	x >> y

Power and logarithmic functions

Function	Equivalent to
exp	math.exp(x)
expm1	math.expm1(x)
log	math.log(x)
log10	math.log10(x)
log1p	math.log1p(x)
log2	math.log2(x)
sqrt	math.sqrt(x)

Hyperbolic functions

Function	Equivalent to
acosh	math.acosh(x)
asinh	math.asinh(x)
atanh	math.atanh(x)
cosh	math.cosh(x)
sinh	math.sinh(x)
tanh	math.tanh(x)

Trigonometric functions

Function	Equivalent to
acos	math.acos(x)
asin	math.asin(x)

atan	math.atan(x)
atan2	math.atan2(x, y)
cos	math.cos(x)
hypot	math.hypot(x, y)
sin	math.sin(x)
tan	math.tan(x)

Angular conversion

Function	Equivalent to
degrees	math.degrees(x)
radians	math.radians(x)

Number-theoretic and representation functions

Function	Equivalent to
ceil	math.ceil(x)
copysign	math.copysign(x, y)
fabs	math.fabs(x)
factorial	math.factorial(x)
floor	math.floor(x)
fmod	math.fmod(x, y)
isfinite	math.isfinite(x)
isinf	math.isinf(x)
isnan	math.isnan(x)
ldexp	math.ldexp(x, y)
trunc	math.trunc(x)

Special functions

Function	Equivalent to
erf	math.erf(x)
erfc	math.erfc(x)
gamma	math.gamma(x)
lgamma	math.lgamma(x)

Additional functions

Function	Equivalent to
fma	fma(x, y, z) or x * y + z

Array Limit Attributes

In addition to functions, a set of attributes are provided representing the platform specific maximum and minimum numerical values for each array type. These attributes are part of the "arraylimits" module.

Searching and Summarising Arrays.

Comparison Operators

Some functions use comparison operators. These are unicode strings containing the Python compare operators and include following:

Operator	Description
'<'	Less than.
'<='	Less than or equal to.
'>'	Greater than.
'>='	Greater than or equal to.
'=='	Equal to.
'!='	Not equal to.

All comparison operators must contain only the above characters and may not include any leading or trailing spaces or other characters.

Description

count

Fill an array with evenly spaced values using a start and step values. The function continues until the end of the array. The function does not check for integer overflow.

count(dataarray, start, step)

- dataarray - The output array.
- start - The numeric value to start from.
- step - The value to increment by when creating each element. This parameter is optional. If it is omitted, a value of 1 is assumed. A negative step value will cause the function to count down.

example:

```
dataarray = array.array('i', [0]*10)
arrayfunc.count(dataarray, 0, 5)
==> array('i', [0, 5, 10, 15, 20, 25, 30, 35, 40, 45])
arrayfunc.count(dataarray, 99)
==> array('i', [99, 100, 101, 102, 103, 104, 105, 106, 107, 108])
arrayfunc.count(dataarray, 29, -8)
==> array('i', [29, 21, 13, 5, -3, -11, -19, -27, -35, -43])
dataarray = array.array('b', [0]*10)
arrayfunc.count(dataarray, 52, 10)
==> array('b', [52, 62, 72, 82, 92, 102, 112, 122, -124, -114])
```

cycle

Fill an array with evenly spaced values using a start, stop, and step values, and repeat until the array is filled.

cycle(dataarray, start, stop, step)

- dataarray - The output array.
- start - The numeric value to start from.
- stop - The value at which to stop incrementing. If stop is less than start, cycle will count down.
- step - The value to increment by when creating each element. This parameter is optional. If it is omitted, a value of 1 is assumed. The sign is ignored and the absolute value used when incrementing.

example:

```
dataarray = array.array('i', [0]*100)
arrayfunc.cycle(dataarray, 0, 25, 5)
==> array('i', [0, 5, 10, 15, 20, 25, 0, 5, ... , 10, 15])
arrayfunc.cycle(dataarray, 5, 30)
==> array('i', [5, 6, 7, 8, 9, 10, ... 28, 29, 30, 5, ... , 24, 25, 26])
dataarray = array.array('i', [0]*10)
arrayfunc.cycle(dataarray, 10, 5, 1)
==> array('i', [10, 9, 8, 7, 6, 5, 10, 9, 8, 7])
arrayfunc.cycle(dataarray, -2, 3, 1)
==> array('i', [-2, -1, 0, 1, 2, 3, -2, -1, 0, 1])
```

repeat

Fill an array with a specified value.

repeat(dataarray, value)

- dataarray - The output array.
- value - The value to use to fill the array.

example:

```
dataarray = array.array('i', [0]*100)
arrayfunc.repeat(dataarray, 99)
==> array('i', [99, 99, 99, 99, ... , 99, 99])
```

afilter

Select values from an array based on a boolean criteria.

x = afilter(op, inparray, outparray, rparam)

x = afilter(op, inparray, outparray, rparam, maxlen=500)

- op - The arithmetic comparison operation.
- inparray - The input data array to be filtered.
- outparray - The output array.
- rparam - The 'y' parameter to be applied to 'op'.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.

- x - An integer count of the number of items filtered into outparray.

example:

```
inparray = array.array('i', [1, 2, 5, 33, 54, -6])
outparray = array.array('i', [0]*6)
x = arrayfunc.afilter('>', inparray, outparray, 10)
==> array('i', [33, 54, 0, 0, 0, 0])
==> x equals 2
x = arrayfunc.afilter('>', inparray, outparray, 10, maxlen=4)
==> array('i', [33, 0, 0, 0, 0, 0])
==> x equals 1
```

compress

Select values from an array based on another array of integers values. The selector array is interpreted as a set of boolean values, where any value other than *0* causes the value in the input array to be selected and copied to the output array, while a value of *0* causes the value to be ignored.

The input, selector, and output arrays need not be of the same length. The copy operation will be terminated when the end of the input or output array is reached. The selector array will be cycled through repeatedly as many times as necessary until the end of the input or output array is reached.

x = compress(inparray, outparray, selectorarray)

x = compress(inparray, outparray, selectorarray, maxlen=500)

- inparray - The input data array to be filtered.
- outparray - The output array.
- selectorarray - The selector array.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- x - An integer count of the number of items filtered into outparray.

example:

```
inparray = array.array('i', [1, 2, 5, 33, 54, -6])
outparray = array.array('i', [0]*6)
selectorarray = array.array('i', [0, 1, 0, 1])
x = arrayfunc.compress(inparray, outparray, selectorarray)
==> array('i', [2, 33, -6, 0, 0, 0])
==> x equals 3
x = arrayfunc.compress(inparray, outparray, selectorarray, maxlen=4)
==> array('i', [2, 33, 0, 0, 0, 0])
==> x equals 2
```

dropwhile

Select values from an array starting from where a selected criteria fails and proceeding to the end.

x = dropwhile(op, inparray, outparray, rparam)

x = dropwhile(op, inparray, outparray, rparam, maxlen=500)

- op - The arithmetic comparison operation.
- inparray - The input data array to be filtered.

- outparray - The output array.
- rparam - The 'y' parameter to be applied to 'op'.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- x - An integer count of the number of items filtered into outparray.

example:

```
inparray = array.array('i', [1, 2, 5, 33, 54, -6])
outparray = array.array('i', [0]*6)
x = arrayfunc.dropwhile('<', inparray, outparray, 10)
==> array('i', [33, 54, 0, 0, 0, 0])
==> x equals 3
x = arrayfunc.dropwhile('<', inparray, outparray, 10, maxlen=5)
==> array('i', [33, 54, 0, 0, 0, 0])
==> x equals 2
```

takewhile

Like dropwhile, but starts from the beginning and stops when the criteria fails.

example:

```
inparray = array.array('i', [1, 2, 5, 33, 54, -6])
outparray = array.array('i', [0]*6)
x = arrayfunc.takewhile('<', inparray, outparray, 10)
==> array('i', [1, 2, 5, 0, 0, 0])
==> x equals 3
x = arrayfunc.takewhile('<', inparray, outparray, 10, maxlen=2)
==> array('i', [1, 2, 0, 0, 0, 0])
==> x equals 2
```

aany

Returns True if any element in an array meets the selected criteria.

x = aany(op, inparray, rparam)

x = aany(op, inparray, rparam, maxlen=500, nosimd=True)

- op - The arithmetic comparison operation.
- inparray - The input data array to be examined.
- rparam - The 'y' parameter to be applied to 'op'.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- nosimd - If true, use of SIMD is disabled.
- x - The boolean result.

example:

```
inparray = array.array('i', [1, 2, 5, 33, 54, -6])
x = arrayfunc.aany('==', inparray, 5)
```

```
==> x equals True
x = arrayfunc.aany('==', inparray, 54, maxlen=5)
==> x equals True
x = arrayfunc.aany('==', inparray, -6, maxlen=5)
==> x equals False
```

aall

Returns True if all elements in an array meet the selected criteria.

x = aall(op, inparray, rparam)

x = aall(op, inparray, rparam, maxlen=500, nosimd=True)

- op - The arithmetic comparison operation.
- inparray - The input data array to be examined.
- rparam - The 'y' parameter to be applied to 'op'.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- nosimd - If true, use of SIMD is disabled.
- x - The boolean result.

example:

```
inparray = array.array('i', [1, 2, 5, 33, 54, -6])
x = arrayfunc.aall('<', inparray, 66)
==> x equals True
x = arrayfunc.aall('<', inparray, 66, maxlen=5)
==> x equals True
inparray = array.array('i', [1, 2, 5, 33, 54, 66])
x = arrayfunc.aall('<', inparray, 66)
==> x equals False
x = arrayfunc.aall('<', inparray, 66, maxlen=5)
==> x equals True
```

amax

Returns the maximum value in the array.

x = amax(inparray)

x = amax(inparray, maxlen=500)

x = amax(inparray, maxlen=500, nosimd=True)

- inparray - The input data array to be examined.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- nosimd - If true, use of SIMD is disabled.
- x - The maximum value.

example:

```
inparray = array.array('i', [1, 2, 5, 33, 54, -6])
x = arrayfunc.amax(inparray)
==> x equals 54
x = arrayfunc.amax(inparray, maxlen=3)
==> x equals 5
```

amin

Returns the minimum value in the array.

x = amin(inparray)

x = amin(inparray, maxlen=500)

x = amin(inparray, maxlen=500, nosimd=True)

- inparray - The input data array to be examined.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- nosimd - If true, use of SIMD is disabled.
- x - The minimum value.

example:

```
inparray = array.array('i', [1, 2, 5, 33, 54, -6])
x = arrayfunc.amin(inparray)
==> x equals -6
x = arrayfunc.amin(inparray, maxlen=3)
==> x equals 1
```

findindex

Returns the index of the first value in an array to meet the specified criteria.

x = findindex(op, inparray, rparam)

x = findindex(op, inparray, rparam, maxlen=500, nosimd=True)

- op - The arithmetic comparison operation.
- inparray - The input data array to be examined.
- rparam - The 'y' parameter to be applied to 'op'.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- nosimd - If true, use of SIMD is disabled.
- x - The resulting index. This will be negative if no match was found.

example:

```
inparray = array.array('i', [1, 2, 5, 33, 54, -6])
x = arrayfunc.findindex('==', inparray, 54)
==> x equals 4
x = arrayfunc.findindex('==', inparray, 54, maxlen=4)
==> x equals -1  (not found)
```

findindices

Searches an array for the array indices which meet the specified criteria and writes the results to a second array. Also returns the number of matches found.

x = findindices(op, inparray, outparray, rparam)

x = findindices(op, inparray, outparray, rparam, maxlen=500)

- op - The arithmetic comparison operation.
- inparray - The input data array to be examined.
- outparray - The output array. This must be an integer array of array type 'q' (signed long long).
- rparam - The 'y' parameter to be applied to 'op'.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- x - An integer indicating the number of matches found.

example:

```
inparray = array.array('i', [1, 2, 5, 33, 54, -6])
outparray = array.array('q', [0]*6)
x = arrayfunc.findindices('<', inparray, outparray, 5)
==> ('i', [0, 1, 5, 0, 0, 0])
==> x equals 3
x = arrayfunc.findindices('<', inparray, outparray, 5, maxlen=4)
==> array('q', [0, 1, 0, 0, 0, 0])
==> x equals 2
```

asum

Calculate the arithmetic sum of an array.

For integer arrays, the intermediate sum is accumulated in the largest corresponding integer size. Signed integers are accumulated in the equivalent to an 'l' array type, and unsigned integers are accumulated in the equivalent to an 'L' array type. This means that integer arrays using smaller integer word sizes cannot overflow unless extremenly large arrays are used (and may be impossible due to limits on array indices in the array module).

asum(inparray)

asum(inparray, matherrors=True, maxlen=5, nosimd=True)

- inparray - The array to be summed.
- matherrors - If this keyword parameter is True, numeric overflow checking will be disabled. This is an optional parameter.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- nosimd - If true, use of SIMD is disabled. SIMD will only be enabled if overflow checking is also disabled.

example:

```
inparray = array.array('i', [1, 2, 5, 33, 54, 6])
arrayfunc.asum(inparray)
```

```
==> 101
inparray = array.array('i', [1, 2, 5, -88, -5, 2])
arrayfunc.asum(inparray, matherrors=True)
==> -83
inparray = array.array('i', [1, 2, 5, -88, -5, 2])
arrayfunc.asum(inparray, maxlen=5)
==> -85
```

convert

Convert arrays between data types. The data will be converted into the form required by the output array. If any values in the input array are outside the range of the output array type, an exception will be raised. When floating point values are converted to integers, the value will be truncated.

convert(inparray, outparray)

convert(inparray, outparray, maxlen=500)

- inparray - The input data array to be examined.
- outparray - The output array.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.

example:

```
inparray = array.array('i', [1, 2, 5, 33, 54, -6])
outparray = array.array('d', [0.0]*6)
arrayfunc.convert(inparray, outparray)
==> ('d', [1.0, 2.0, 5.0, 33.0, 54.0, -6.0])
inparray = array.array('d', [5.7654]*10)
outparray = array.array('h', [0]*10)
arrayfunc.convert(inparray, outparray)
==> array('h', [5, 5, 5, 5, 5, 5, 5, 5, 5, 5])
inparray = array.array('d', [5.7654]*10)
outparray = array.array('h', [0]*10)
arrayfunc.convert(inparray, outparray, maxlen=5)
==> array('h', [5, 5, 5, 5, 5, 0, 0, 0, 0, 0])
```

arraylimits attributes

A set of attributes are provided representing the platform specific maximum and minimum numerical values for each array type. These attributes are part of the "arraylimits" module.

Array integer sizes may differ on 32 versus 64 bit versions, plus other platform characteristics may also produce differences.

Array Type Code	Description	Min Value	Max Value
b	signed char	b_min	b_max
B	unsigned char	B_min	B_max
h	signed short	h_min	h_max
H	unsigned short	H_min	H_max
i	signed int	i_min	i_max
I	unsigned int	I_min	I_max

l	signed long	l_min	l_max
L	unsigned long	L_min	L_max
q	signed long long	q_min	q_max
Q	unsigned long long	Q_min	Q_max
f	float	f_min	f_max
d	double	d_min	d_max

example:

```
import arrayfunc
from arrayfunc import arraylimits

arrayfunc.arraylimits.b_min
==> -128
arrayfunc.arraylimits.b_max
==> 127
arrayfunc.arraylimits.f_min
==> -3.4028234663852886e+38
arrayfunc.arraylimits.f_max
==> 3.4028234663852886e+38
```

Mathematical Functions

Description

Mathematical functions provide similar functionality to the functions of the same name in the standard library "math" and "operator" modules, but operate over whole arrays instead of on a single value.

Mathematical functions can accept a variety of different combinations of array and numerical parameters. Each function will automatically detect the category of parameter and adjust its behaviour accordingly.

Output can be either into a separate output array, or in-place (into the original array) if no output array is provided.

Parameter Forms

This example will subtract 10 from each element of array 'x', replacing the original data.:

```
x = array.array('b', [20,21,22,23,24,25])
arrayfunc.sub(x, 10)
```

This example will do the same, but place the results into array 'z', leaving the original array unchanged.:

```
x = array.array('b', [20,21,22,23,24,25])
z = array.array('b', [0] * len(x))
arrayfunc.sub(x, 10, z)
```

This is similar to the first one, but performs the calculation of '10 - x' instead of 'x - 10'.:

```
x = array.array('b', [20,21,22,23,24,25])
arrayfunc.sub(10, x)
```

This example takes each element of array 'x', adds the corresponding element of array 'y', and puts the result in array 'z'.:

```
x = array.array('b', [20,21,22,23,24,25])
y = array.array('b', [10,5,55,42,42,0])
z = array.array('b', [0] * len(x))
arrayfunc.add(x, y, z)
```

Parameter Type Consistency

Unless otherwise noted, all array and numeric parameters must be of the same type when calling a mathematical function. That is, you may not mix integer and floating point, or different integer sizes in the same calculation. Failing to do so will result in an exception being raised.

Using Less than the Entire Array

If the size of the array is larger than the desired length of the calculation, it may be limited to the first part of the array by using the 'maxlen' parameter. In the following example only the first 3 array elements will be operated on, with the following ones left unchanged.:

```
x = array.array('b', [20,21,22,23,24,25])
arrayfunc.add(x, 10, maxlen=3)
```

Supressing or Ignoring Math Errors

Functions can be made to ignore some mathematical errors (e.g. integer overflow) by setting the 'matherrors' keyword parameter to True.:

```
x = array.array('b', [20,21,22,23,24,25])
arrayfunc.add(x, 235, matherrors=True)
```

However, not all math errors can be supressed, only those which would not otherwise cause a fatal error (e.g. division by zero).

Ignoring errors may be desirable if the side effect (e.g. the result of an integer overflow) is the intended effect, or for reasons of a minor performance improvement in some cases. Note that any such performance improvement will vary greatly depending upon the specific function and array type. Benchmark your calculation before deciding if this is worth while.

Differences with Native Python

In many cases the Python 'math' module functions are thin wrappers around the underlying C library, as is 'arrayfunc'.

However, in some cases 'arrayfunc' will not produce exactly the same result as Python. There are several reasons for this, the primary one being that arrayfunc operates on different underlying data types. Specifically, arrayfunc uses the platform's native integer and floating point types as exposed by the array module. For example, Python integers are of arbitrary size and can never overflow (Python simply expands the word size indefinitely), while arrayfunc integers will overflow the same as they would with programs written in C.

Think of arrayfunc as exposing C style semantics in a form convenient to use in Python. Some convenience which Python provides (e.g. no limit to the size of integers) is traded off for large performance increases.

However, Arrayfunc does implement the mod or '%' operator in a manner which is compatible with Python, not 'C'. The C method will produce mathematically incorrect answers under some ranges of values (as will many other programming languages as well as some popular spreadsheets which use the C compiler without correction). Python implements this in a mathematically correct manner in all cases, and Arrayfunc follows suit.

Arrayfunc diverges from Python in the following areas:

- The handling of non-finite floating point values such as 'NaN' (not-a-number) and +/-Inf in calculations may not always be compatible.
- The 'floor' function will return a floating point value when floating point arrays are used, rather than an integer. This is necessary to maintain compatibility with the array parameters.
- Floordiv does not behave the same as '//' when working with infinity. When dividing positive or negative infinity by any number, the arrayfunc version of floordiv will return +/- infinity, while the Python '//' operator will return 'NaN' (not-a-number) in each case.
- Binary operations such as shift and invert will operate according to their native array data types, which may differ from Python's own integer implementation. This is necessary because the array integer is of fixed size (Python integers can be infinitely large) and has both signed and unsigned types (Python integers are signed only).
- "Mod" does not behave exactly as "%" does for floating point. X % inf and x % -inf will return nan rather than +/- inf.
- The type of exception raised when an error is encountered in Python versus arrayfunc may not be the same in all cases.

Other Notes

- Ldexp only accepts an integer number as the second parameter, not an array.
- Math.pow is not implemented because it duplicates the operator pow (and the names would collide in arrayfunc).
- Fma is not part of the Python standard library, but has been offered here as an additional feature.

Mathematical operator functions

add

Calculate add over the values in an array.

Equivalent to:	x + y
Array types supported:	b, B, h, H, i, I, l, L, q, Q, f, d
Exceptions raised:	OverflowError, ArithmeticError

Call formats:

```
add(array1, param)
add(array1, param, outparray)
add(param, array1)
add(param, array1, outparray)
add(array1, array2)
add(array1, array2, outparray)
add(array1, param, maxlen=y)
add(array1, param, matherrors=False)
add(array1, param, nosimd=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

truediv

Calculate truediv over the values in an array.

Equivalent to:	x / y
Array types supported:	b, B, h, H, i, I, l, L, q, Q, f, d
Exceptions raised:	OverflowError, ArithmeticError, ZeroDivisionError

Call formats:

```
truediv(array1, param)
truediv(array1, param, outparray)
truediv(param, array1)
truediv(param, array1, outparray)
truediv(array1, array2)
truediv(array1, array2, outparray)
truediv(array1, param, maxlen=y)
truediv(array1, param, matherrors=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

floordiv

Calculate floordiv over the values in an array.

Equivalent to:	x // y
Array types supported:	b, B, h, H, i, I, l, L, q, Q, f, d
Exceptions raised:	OverflowError, ArithmeticError, ZeroDivisionError

Call formats:

```
floordiv(array1, param)
floordiv(array1, param, outparray)
floordiv(param, array1)
floordiv(param, array1, outparray)
floordiv(array1, array2)
floordiv(array1, array2, outparray)
floordiv(array1, param, maxlen=y)
floordiv(array1, param, matherrors=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

mod

Calculate mod over the values in an array.

Equivalent to:	x % y
Array types supported:	b, B, h, H, i, I, l, L, q, Q, f, d
Exceptions raised:	OverflowError, ArithmeticError, ZeroDivisionError

Call formats:

```
mod(array1, param)
mod(array1, param, outparray)
mod(param, array1)
mod(param, array1, outparray)
mod(array1, array2)
mod(array1, array2, outparray)
mod(array1, param, maxlen=y)
mod(array1, param, matherrors=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.

- matherrors - If true, arithmetic error checking is disabled. The default is false.

mul

Calculate mul over the values in an array.

Equivalent to:	x * y
Array types supported:	b, B, h, H, i, I, l, L, q, Q, f, d
Exceptions raised:	OverflowError, ArithmeticError

Call formats:

```
mul(array1, param)
mul(array1, param, outparray)
mul(param, array1)
mul(param, array1, outparray)
mul(array1, array2)
mul(array1, array2, outparray)
mul(array1, param, maxlen=y)
mul(array1, param, matherrors=False)
mul(array1, param, nosimd=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

neg

Calculate neg over the values in an array.

Equivalent to:	-x
Array types supported:	b, h, i, l, q, f, d
Exceptions raised:	OverflowError, ArithmeticError

Call formats:

```
neg(array1)
neg(array1, outparray)
neg(array1, maxlen=y)
neg(array1, matherrors=False))
neg(array1, nosimd=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

pow

Calculate pow over the values in an array.

Equivalent to:	x**y or math.pow(x, y)
Array types supported:	b, B, h, H, i, I, l, L, q, Q, f, d
Exceptions raised:	OverflowError, ArithmeticError

Call formats:

```
pow(array1, param)
pow(array1, param, outparray)
pow(param, array1)
pow(param, array1, outparray)
pow(array1, array2)
pow(array1, array2, outparray)
pow(array1, param, maxlen=y)
pow(array1, param, matherrors=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

sub

Calculate sub over the values in an array.

Equivalent to:	x - y
Array types supported:	b, B, h, H, i, I, l, L, q, Q, f, d
Exceptions raised:	OverflowError, ArithmeticError

Call formats:

```
sub(array1, param)
sub(array1, param, outparray)
sub(param, array1)
```

```
sub(param, array1, outparray)
sub(array1, array2)
sub(array1, array2, outparray)
sub(array1, param, maxlen=y)
sub(array1, param, matherrors=False)
sub(array1, param, nosimd=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

*abs_*

Calculate abs_ over the values in an array.

Equivalent to:	abs(x)
Array types supported:	b, h, i, l, q, f, d
Exceptions raised:	OverflowError

Call formats:

```
abs_(array1)
abs_(array1, outparray)
abs_(array1, maxlen=y)
abs_(array1, matherrors=False))
abs_(array1, nosimd=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

Comparison operator functions

eq

Calculate eq over the values in an array.

Equivalent to:	x == y

Array types supported:	b, B, h, H, i, I, l, L, q, Q, f, d
Exceptions raised:	

Call formats:

```
result = eq(array1, param)
result = eq(param, array1)
result = eq(array1, array2)
result = eq(array1, param, maxlen=y)
result = eq(array1, param, nosimd=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- result - A boolean value corresponding to the result of all the comparison operations. If all comparison operations result in true, the return value will be true. If any of them result in false, the return value will be false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

gt

Calculate gt over the values in an array.

Equivalent to:	x > y
Array types supported:	b, B, h, H, i, I, l, L, q, Q, f, d
Exceptions raised:	

Call formats:

```
result = gt(array1, param)
result = gt(param, array1)
result = gt(array1, array2)
result = gt(array1, param, maxlen=y)
result = gt(array1, param, nosimd=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.

- result - A boolean value corresponding to the result of all the comparison operations. If all comparison operations result in true, the return value will be true. If any of them result in false, the return value will be false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

ge

Calculate ge over the values in an array.

Equivalent to:	x >= y
Array types supported:	b, B, h, H, i, I, l, L, q, Q, f, d
Exceptions raised:	

Call formats:

```
result = ge(array1, param)
result = ge(param, array1)
result = ge(array1, array2)
result = ge(array1, param, maxlen=y)
result = ge(array1, param, nosimd=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- result - A boolean value corresponding to the result of all the comparison operations. If all comparison operations result in true, the return value will be true. If any of them result in false, the return value will be false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

lt

Calculate lt over the values in an array.

Equivalent to:	x < y
Array types supported:	b, B, h, H, i, I, l, L, q, Q, f, d
Exceptions raised:	

Call formats:

```
result = lt(array1, param)
result = lt(param, array1)
result = lt(array1, array2)
result = lt(array1, param, maxlen=y)
result = lt(array1, param, nosimd=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- result - A boolean value corresponding to the result of all the comparison operations. If all comparison operations result in true, the return value will be true. If any of them result in false, the return value will be false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

le

Calculate le over the values in an array.

Equivalent to:	x <= y
Array types supported:	b, B, h, H, i, I, l, L, q, Q, f, d
Exceptions raised:	

Call formats:

```
result = le(array1, param)
result = le(param, array1)
result = le(array1, array2)
result = le(array1, param, maxlen=y)
result = le(array1, param, nosimd=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- result - A boolean value corresponding to the result of all the comparison operations. If all comparison operations result in true, the return value will be true. If any of them result in false, the return value will be false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

ne

Calculate ne over the values in an array.

Equivalent to:	x != y
Array types supported:	b, B, h, H, i, I, l, L, q, Q, f, d
Exceptions raised:	

Call formats:

```
result = ne(array1, param)
result = ne(param, array1)
result = ne(array1, array2)
result = ne(array1, param, maxlen=y)
result = ne(array1, param, nosimd=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- result - A boolean value corresponding to the result of all the comparison operations. If all comparison operations result in true, the return value will be true. If any of them result in false, the return value will be false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

Bitwise operator functions

*and_*

Calculate and_ over the values in an array.

Equivalent to:	x & y
Array types supported:	b, B, h, H, i, I, l, L, q, Q
Exceptions raised:	

Call formats:

```
and_(array1, param)
and_(array1, param, outparray)
and_(param, array1)
and_(param, array1, outparray)
and_(array1, array2)
and_(array1, array2, outparray)
and_(array1, param, maxlen=y)
and_(array1, param, nosimd=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.

- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

*or_*

Calculate or_ over the values in an array.

Equivalent to:	x | y
Array types supported:	b, B, h, H, i, I, l, L, q, Q
Exceptions raised:	

Call formats:

```
or_(array1, param)
or_(array1, param, outparray)
or_(param, array1)
or_(param, array1, outparray)
or_(array1, array2)
or_(array1, array2, outparray)
or_(array1, param, maxlen=y)
or_(array1, param, nosimd=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

xor

Calculate xor over the values in an array.

Equivalent to:	x ^ y
Array types supported:	b, B, h, H, i, I, l, L, q, Q
Exceptions raised:	

Call formats:

```
xor(array1, param)
xor(array1, param, outparray)
xor(param, array1)
xor(param, array1, outparray)
xor(array1, array2)
xor(array1, array2, outparray)
```

```
xor(array1, param, maxlen=y)
xor(array1, param, nosimd=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

invert

Calculate invert over the values in an array.

Equivalent to:	~x
Array types supported:	b, B, h, H, i, I, l, L, q, Q
Exceptions raised:	

Call formats:

```
invert(array1)
invert(array1, outparray)
invert(array1, maxlen=y)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.

lshift

Calculate lshift over the values in an array.

Equivalent to:	x << y
Array types supported:	b, B, h, H, i, I, l, L, q, Q
Exceptions raised:	

Call formats:

```
lshift(array1, param)
lshift(array1, param, outparray)
lshift(param, array1)
lshift(param, array1, outparray)
lshift(array1, array2)
```

```
lshift(array1, array2, outparray)
lshift(array1, param, maxlen=y)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.

rshift

Calculate rshift over the values in an array.

Equivalent to:	x >> y
Array types supported:	b, B, h, H, i, I, l, L, q, Q
Exceptions raised:	

Call formats:

```
rshift(array1, param)
rshift(array1, param, outparray)
rshift(param, array1)
rshift(param, array1, outparray)
rshift(array1, array2)
rshift(array1, array2, outparray)
rshift(array1, param, maxlen=y)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.

Power and logarithmic functions

exp

Calculate exp over the values in an array.

Equivalent to:	math.exp(x)
Array types supported:	f, d

Exceptions raised:	ArithmeticError

Call formats:

```
exp(array1)
exp(array1, outparray)
exp(array1, maxlen=y)
exp(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

expm1

Calculate expm1 over the values in an array.

Equivalent to:	math.expm1(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
expm1(array1)
expm1(array1, outparray)
expm1(array1, maxlen=y)
expm1(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

log

Calculate log over the values in an array.

Equivalent to:	math.log(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
log(array1)
log(array1, outparray)
log(array1, maxlen=y)
log(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

log10

Calculate log10 over the values in an array.

Equivalent to:	math.log10(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
log10(array1)
log10(array1, outparray)
log10(array1, maxlen=y)
log10(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

log1p

Calculate log1p over the values in an array.

Equivalent to:	math.log1p(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
log1p(array1)
log1p(array1, outparray)
log1p(array1, maxlen=y)
log1p(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

log2

Calculate log2 over the values in an array.

Equivalent to:	math.log2(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
log2(array1)
log2(array1, outparray)
log2(array1, maxlen=y)
log2(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

sqrt

Calculate sqrt over the values in an array.

Equivalent to:	math.sqrt(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
sqrt(array1)
sqrt(array1, outparray)
sqrt(array1, maxlen=y)
sqrt(array1, matherrors=False))
sqrt(array1, nosimd=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.

- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

Hyperbolic functions

acosh

Calculate acosh over the values in an array.

Equivalent to:	math.acosh(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
acosh(array1)
acosh(array1, outparray)
acosh(array1, maxlen=y)
acosh(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

asinh

Calculate asinh over the values in an array.

Equivalent to:	math.asinh(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
asinh(array1)
asinh(array1, outparray)
asinh(array1, maxlen=y)
asinh(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.

- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

atanh

Calculate atanh over the values in an array.

Equivalent to:	math.atanh(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
atanh(array1)
atanh(array1, outparray)
atanh(array1, maxlen=y)
atanh(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

cosh

Calculate cosh over the values in an array.

Equivalent to:	math.cosh(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
cosh(array1)
cosh(array1, outparray)
cosh(array1, maxlen=y)
cosh(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

sinh

Calculate sinh over the values in an array.

Equivalent to:	math.sinh(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
sinh(array1)
sinh(array1, outparray)
sinh(array1, maxlen=y)
sinh(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

tanh

Calculate tanh over the values in an array.

Equivalent to:	math.tanh(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
tanh(array1)
tanh(array1, outparray)
tanh(array1, maxlen=y)
tanh(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

Trigonometric functions

acos

Calculate acos over the values in an array.

Equivalent to:	math.acos(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
acos(array1)
acos(array1, outparray)
acos(array1, maxlen=y)
acos(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

asin

Calculate asin over the values in an array.

Equivalent to:	math.asin(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
asin(array1)
asin(array1, outparray)
asin(array1, maxlen=y)
asin(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

atan

Calculate atan over the values in an array.

Equivalent to:	math.atan(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
atan(array1)
atan(array1, outparray)
atan(array1, maxlen=y)
atan(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

atan2

Calculate atan2 over the values in an array.

Equivalent to:	math.atan2(x, y)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
atan2(array1, param)
atan2(array1, param, outparray)
atan2(param, array1)
atan2(param, array1, outparray)
atan2(array1, array2)
atan2(array1, array2, outparray)
atan2(array1, param, maxlen=y)
atan2(array1, param, matherrors=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

cos

Calculate cos over the values in an array.

Equivalent to:	math.cos(x)

Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
cos(array1)
cos(array1, outparray)
cos(array1, maxlen=y)
cos(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

hypot

Calculate hypot over the values in an array.

Equivalent to:	math.hypot(x, y)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
hypot(array1, param)
hypot(array1, param, outparray)
hypot(param, array1)
hypot(param, array1, outparray)
hypot(array1, array2)
hypot(array1, array2, outparray)
hypot(array1, param, maxlen=y)
hypot(array1, param, matherrors=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

sin

Calculate sin over the values in an array.

Equivalent to:	math.sin(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
sin(array1)
sin(array1, outparray)
sin(array1, maxlen=y)
sin(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

tan

Calculate tan over the values in an array.

Equivalent to:	math.tan(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
tan(array1)
tan(array1, outparray)
tan(array1, maxlen=y)
tan(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

Angular conversion

degrees

Calculate degrees over the values in an array.

Equivalent to:	math.degrees(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
degrees(array1)
degrees(array1, outparray)
degrees(array1, maxlen=y)
degrees(array1, matherrors=False))
degrees(array1, nosimd=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

radians

Calculate radians over the values in an array.

Equivalent to:	math.radians(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
radians(array1)
radians(array1, outparray)
radians(array1, maxlen=y)
radians(array1, matherrors=False))
radians(array1, nosimd=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

Number-theoretic and representation functions

ceil

Calculate ceil over the values in an array.

Equivalent to:	math.ceil(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
ceil(array1)
ceil(array1, outparray)
ceil(array1, maxlen=y)
ceil(array1, matherrors=False))
ceil(array1, nosimd=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

copysign

Calculate copysign over the values in an array.

Equivalent to:	math.copysign(x, y)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
copysign(array1, param)
copysign(array1, param, outparray)
copysign(param, array1)
copysign(param, array1, outparray)
copysign(array1, array2)
copysign(array1, array2, outparray)
copysign(array1, param, maxlen=y)
copysign(array1, param, matherrors=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.

- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

fabs

Calculate fabs over the values in an array.

Equivalent to:	math.fabs(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
fabs(array1)
fabs(array1, outparray)
fabs(array1, maxlen=y)
fabs(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

factorial

Calculate factorial over the values in an array.

Equivalent to:	math.factorial(x)
Array types supported:	b, B, h, H, i, I, l, L, q, Q
Exceptions raised:	OverflowError

Call formats:

```
factorial(array1)
factorial(array1, outparray)
factorial(array1, maxlen=y)
factorial(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

floor

Calculate floor over the values in an array.

Equivalent to:	math.floor(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
floor(array1)
floor(array1, outparray)
floor(array1, maxlen=y)
floor(array1, matherrors=False))
floor(array1, nosimd=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

fmod

Calculate fmod over the values in an array.

Equivalent to:	math.fmod(x, y)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
fmod(array1, param)
fmod(array1, param, outparray)
fmod(param, array1)
fmod(param, array1, outparray)
fmod(array1, array2)
fmod(array1, array2, outparray)
fmod(array1, param, maxlen=y)
fmod(array1, param, matherrors=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- param - A non-array numeric parameter.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- outparray - The output array. This parameter is optional.

- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

isfinite

Calculate isfinite over the values in an array.

Equivalent to:	math.isfinite(x)
Array types supported:	f, d
Exceptions raised:	

Call formats:

```
result = isfinite(array1)
result = isfinite(array1, maxlen=y)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- result - A boolean value corresponding to the result of all the comparison operations. If at least one comparison operation results in true, the return value will be true. If none of them result in true, the return value will be false.

isinf

Calculate isinf over the values in an array.

Equivalent to:	math.isinf(x)
Array types supported:	f, d
Exceptions raised:	

Call formats:

```
result = isinf(array1)
result = isinf(array1, maxlen=y)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- result - A boolean value corresponding to the result of all the comparison operations. If at least one comparison operation results in true, the return value will be true. If none of them result in true, the return value will be false.

isnan

Calculate isnan over the values in an array.

Equivalent to:	math.isnan(x)
Array types supported:	f, d
Exceptions raised:	

Call formats:

```
result = isnan(array1)
result = isnan(array1, maxlen=y)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- result - A boolean value corresponding to the result of all the comparison operations. If at least one comparison operation results in true, the return value will be true. If none of them result in true, the return value will be false.

ldexp

Calculate ldexp over the values in an array.

Equivalent to:	math.ldexp(x, y)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
ldexp(array1, exp)
ldexp(array1, exp, outparray)
ldexp(array1, exp, maxlen=y)
ldexp(array1, exp, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- exp - The exponent to apply to the input array. This must be an integer.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

trunc

Calculate trunc over the values in an array.

Equivalent to:	math.trunc(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
trunc(array1)
trunc(array1, outparray)
trunc(array1, maxlen=y)
trunc(array1, matherrors=False))
trunc(array1, nosimd=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.
- nosimd - If True, SIMD acceleration is disabled. This parameter is optional. The default is FALSE.

Special functions

erf

Calculate erf over the values in an array.

Equivalent to:	math.erf(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
erf(array1)
erf(array1, outparray)
erf(array1, maxlen=y)
erf(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

erfc

Calculate erfc over the values in an array.

Equivalent to:	math.erfc(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
erfc(array1)
erfc(array1, outparray)
erfc(array1, maxlen=y)
erfc(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

gamma

Calculate gamma over the values in an array.

Equivalent to:	math.gamma(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
gamma(array1)
gamma(array1, outparray)
gamma(array1, maxlen=y)
gamma(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

lgamma

Calculate lgamma over the values in an array.

Equivalent to:	math.lgamma(x)
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
lgamma(array1)
lgamma(array1, outparray)
```

```
lgamma(array1, maxlen=y)
lgamma(array1, matherrors=False))
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

Additional functions

fma

Calculate fma over the values in an array.

Equivalent to:	fma(x, y, z) or x * y + z
Array types supported:	f, d
Exceptions raised:	ArithmeticError

Call formats:

```
fma(array1, array2, array3)
fma(array1, array2, array3, outparray)
fma(array1, array2, param3)
fma(array1, array2, param3, outparray)
fma(array1, param2, array3)
fma(array1, param2, array3, outparray)
fma(array1, param2, param3)
fma(array1, param2, param3, outparray)
fma(array1, array2, array3, maxlen=y)
fma(array1, array2, array3, matherrors=False)
```

- array1 - The first input data array to be examined. If no output array is provided the results will overwrite the input data.
- array2 - A second input data array. Each element in this array is applied to the corresponding element in the first array.
- param2 - A non-array numeric parameter which is used in place of array2.
- array3 - A third input data array. Each element in this array is applied to the corresponding element in the first array.
- param3 - A non-array numeric parameter which is used in place of array3.
- outparray - The output array. This parameter is optional.
- maxlen - Limit the length of the array used. This must be a valid positive integer. If a zero or negative length, or a value which is greater than the actual length of the array is specified, this parameter is ignored.
- matherrors - If true, arithmetic error checking is disabled. The default is false.

Option Flags and Parameters

Arithmetic Overflow Control

Many functions allow integer overflow detection to be turned off if desired. See the list of operators for which operators this applies to.

Integer overflow is when a number becomes too large to fit within the specified word size for that array data type. For example, an unsigned char has a range of 0 to 255. When a calculation overflows, it "wraps around" one or more times and produces an arithmetically invalid result.

If it is known in advance that overflow cannot occur (due to the size of the numbers), or if overflow is a desired side effect, then overflow checking may be disabled via the "matherrors" parameter. Setting "matherrors" to true will *disable* overflow checking, while setting it to false will *enable* overflow checking. Checking is enabled by default, including when the "matherrors" parameter is not specified.

Disabling overflow checking can significantly increase the speed of calculation, with the amount of improvement depending on the type of calculation being performed and the data type used.

Using Only Part of an Array

The array math functions only use existing arrays that the user provides and do not create new arrays or resize existing ones. The reason for this is that when very large arrays are being used, continually allocating and de-allocating arrays can take too much time, plus this may result in problems controlling how much memory is used.

Since the filter functions (or other data sources) may not use all of an output array, and the result may vary depending on the data, most functions provide an optional keyword parameter which limits the functions to part of the array. The "maxlen" parameter specifies the maximum number of array elements to use, starting from the beginning of the array.

For example, specifying a "maxlen" of 10 for a 20 element array will limit a function to using only the first 10 array elements and ignoring the rest of the array.

If the array length limit value is zero, negative, or greater than the actual size of the array, the length limit will be ignored and the entire array used. The default is to use the entire array.

SIMD Control

SIMD (Single Instruction Multiple Data) is a set of CPU features which allow multiple operations to take place in parallel. Some, but not all, functions will make use of these instructions to speed up execution.

Those functions which do support SIMD features will automatically make use of them by default unless this feature is disabled. There is normally no reason to disable SIMD, but should there be hardware related problems the function can be forced to fall back to conventional execution mode.

If the optional parameter "nosimd" is set to true ("nosimd=True"), SIMD execution will be disabled. The default is "False".

To repeat, there is normally no reason to wish to disable SIMD.

See the documentation section on SIMD support has more detail.

Data Types

Array Types

The following array types from the Python standard library are supported.

Array Type Code	Description
b	signed char
B	unsigned char
h	signed short
H	unsigned short
i	signed int
I	unsigned int
l	signed long
L	unsigned long
q	signed long long
Q	unsigned long long
f	float
d	double

Numeric Parameter Types

Python Type	Description
integer	Integral values such as 0, 1, 100, -99, etc.
floating point	Real numbers such as 0.0, 1.93, 3.1417, -5693.0, etc.

The numeric type must be compatible with the array type code.

The 'L' and 'Q' type parameters cannot be checked for integer overflow due to a mismatch between Python and 'C' language numeric limits.

Maximum Array Size

Arrays are limited to no more than the number of elements defined by the Python C API constant Py_ssize_t. The size of this will depend on your platform characteristics. However, it will normally allow for arrays larger than can be contained in memory for most computers.

When creating very large arrays, it is recommended to consider using itertools.repeat as an initializer or to use array.extend or array.append to add to an array rather than using a list as an intializer. Lists use much more memory than arrays (even for the same data type), and it is easy to run out of memory if you are not careful when creating very large arrays from lists.

Platform Compiler Support

Beginning with version 2.0 of ArrayFunc, versions compiled with the Microsoft MSVS compiler now has feature parity with the GCC version. This change is due to the Microsoft C compiler now supporting a new enough version of the 'C' standard.

Integer Error Checking

Error checking in integer operators is conducted as follows:

Error Categories

Operation	Result out of range	Divide by zero	Negate max. negative signed int	Parameter is negative
Addition (+)	X			
Subtraction (-)	X			
Modulus (%)		X	X	
Multiplication (*)	X			
Division (/, //)		X	X	
Negation (-)			X	
Absolute Value			X	
Factorial	X			X
Power (**)	X			X

- Negation of the maximum negative signed in (the most negative integer for that array type) can be caused by negation, absolute value, division, and modulus operations. Since signed integers do not have a symetrical range (e.g. -128 to 127 for 8 bit sizes) anything which attempts to convert (in this example) -128 to +128 would cause an overflow back to -128.
- The factorial of negative numbers is undefined.
- Powers are not calculated for integers raised to negative powers, as integer arrays cannot contain fractional results.

Disabling Integer Division by Zero Checks

Divison by zero cannot be disabled for integer division or modulus operations. Division by zero could cause seg faults (crashes), so this option is ignored for these functions.

Floating Point NaN and Infinity

Floating point numbers include three special values, NaN (Not a Number), and negative and positive infinity. Arrayfunc uses the platform C compiler to create executable code. Some compilers may produce different results than other compilers under certain conditions when operating on NaN and infinity values. In addition, the Arrayfunc results may differ from those in native Python on some platforms when using NaN and infinity as inputs.

However, since using NaN and infinity as numeric inputs is not a commmon operation, this is unlikely to be a serious problem when writing cross platform code in most cases.

Exceptions

Exceptions - General

The following exceptions apply to most functions.

Exception type	Text	Description
ArithmeticError	arithmetic error in calculation.	An arithmetic error occured in a calculation.

ZeroDivisionError	zero division error in calculation.	A calculation attempted to divide by zero.
IndexError	array length error.	One or more arrays has an invalid length (e.g a length of zero).
IndexError	input array length error.	The input array has an invalid length.
IndexError	output length error.	The output array has an invalid length.
IndexError	array length mismatch.	Two or more arrays which are expected to be of equal length are not.
OverflowError	arithmetic overflow in calculation.	An arithmetic integer overflow ocurred in a calculation.
OverflowError	arithmetic overflow in parameter.	The size or range of a non-array parameter was not compatible with the array parameters.
TypeError	array and parameter type mismatch.	A non-array parameter data type was not compatible with the array parameters.
TypeError	array type mismatch.	An array parameter is not compatible with another array parameter. For most functions, both arrays must be of the same type.
TypeError	unknown array type.	The array type is unknown.
TypeError	array.array expected.	A non-array parameter was found where an array parameter was expected.
ValueError	operator not valid for this function.	An operator parameter used was not valid for this function.
ValueError	operator not valid for this platform.	The operator used is not supported on this platform.
TypeError	parameter error.	An unspecified error occured when parsing the parameters.
TypeError	parameter missing.	An expected parameter was missing.
ValueError	parameter not valid for this operation.	A value is not valid for this operation. E.g. attempting to perform a factorial on a negative number.
IndexError	selector length error.	The selector array length is incorrect.
ValueError	conversion not valid for this type.	The conversion attempted was invalid.
ValueError	cannot convert float NaN to integer.	Cannot convert NaN (Not A Number) floating point value in the input array to integer.
TypeError	output array type invalid.	The output array type is invalid.

SIMD Support

General

SIMD (Single Instruction Multiple Data) is a set of CPU features which allow multiple operations to take place in parallel. Some, but not all, functions will make use of these instructions to speed up execution.

Those functions which do support SIMD features will automatically make use of them by default unless this feature is disabled. There is normally no reason to disable SIMD, but should there be hardware related problems the function can be forced to fall back to conventional execution mode.

Platform Support

SIMD instructions are presently supported only on 64 bit x86 (i.e. AMD64) using the GCC compiler. Other compilers or platforms will still run the same functions and should produce the same results, but they will not benefit from SIMD acceleration.

However, non-SIMD functions will still be much faster standard Python code. See the performance benchmarks to see what the relative speed differences are. With wider data types (e.g. double precision floating point) SIMD provides only marginal speed ups anyway.

Data Type Support

The following table shows which array data types are supported by x86_64 SIMD instructions.

function	b	B	h	H	i	I	l	L	q	Q	f	d
aall	X	X	X	X	X	X					X	X
aany	X	X	X	X	X	X					X	X
abs_	X		X		X							
add	X	X	X	X	X	X					X	X
amax	X	X	X	X	X	X					X	X
amin	X	X	X	X	X	X					X	X
and_	X	X	X	X	X	X						
asum											X	X
ceil											X	X
degrees											X	X
eq	X	X	X	X	X	X					X	X
findindex	X	X	X	X	X	X					X	X
floor											X	X
ge	X	X	X	X	X	X					X	X
gt	X	X	X	X	X	X					X	X
invert	X	X	X	X	X	X						
le	X	X	X	X	X	X					X	X
lt	X	X	X	X	X	X					X	X
mul	X	X	X	X	X	X					X	X
ne	X	X	X	X	X	X					X	X
neg	X		X		X							
or_	X	X	X	X	X	X						
radians											X	X
sqrt											X	X
sub	X	X	X	X	X	X					X	X

trunc											X	X
xor	X	X	X	X	X	X						

SIMD Support Attributes

There is an attribute which can be tested to detect if ArrayFunc is compiled with SIMD support and if the current hardware supports the required SIMD level.

arrayfunc.simdsupport.hassimd

The attribute "hassimd" will be True if the module supports SIMD.

example:

```
import arrayfunc
arrayfunc.simdsupport.hassimd
==> True
```

Performance

Variables affecting Performance

The purpose of the Arrayfunc module is to execute common operations faster than native Python. The relative speed will depend upon a number of factors:

- The function.
- The data type of the array.
- Function options. Turning checking off will result in faster performance.
- The data in the arrays and the parameters.
- The size of the array.
- The platform, including CPU type (e.g. x86 or ARM), operating system, and compiler.

The speeds listed below should be used as rough guidelines only. More exact results will require application specific testing. The numbers shown are the execution time of each function relative to native Python. For example, a value of '50' means that the corresponding Arrayfunc operation ran 50 times faster than the closest native Python equivalent.

Both relative performance (the speed-up as compared to Python) and absolute performance (the actual execution speed of Python and ArrayFunc) will vary significantly depending upon the compiler (which is OS platform dependent) and whether compiled to 32 or 64 bit. If your precise actual benchmark performance results matter, be sure to conduct your testing using the actual OS and compiler your final program will be deployed on. The values listed below were measured on x86-64 Linux compiled with GCC.

Note: Some more complex Arrayfunc functions do not work exactly the same way as the built-in or "itertools" Python equivalents. This means that the benchmark results should be taken as general guidelines rather than precise comparisons.

Typical Performance Readings

Non-Optmised Performance

In this set of tests, all error checking was turned on (the default state) and SIMD acceleration was disabled (not the default).

Relative Performance - Python Time / Arrayfunc Time.

function	b	B	h	H	i	I	l	L	q	Q	f	d
aall	8.7	7.6	10	10	8.6	9.5	8.2	11	8.2	11	13	9.7
aany	5.4	4.7	4.2	4.0	4.2	4.5	3.9	4.5	4.0	5.3	11	6.3
afilter	126	127	127	126	119	101	129	127	114	123	130	120
amax	26	21	23	19	21	23	14	15	15	16	21	21
amin	20	19	24	20	24	20	14	16	14	15	31	29
asum	8.3	9.8	8.3	8.9	7.8	9.2	7.9	8.6	8.2	8.9	6.0	5.8
compress	31	36	40	24	31	17	34	29	38	25	35	34
count	203	212	145	205	142	110	105	109	102	102	73	72
cycle	88	83	83	81	80	66	92	59	91	60	55	54
dropwhile	235	256	248	215	203	196	182	165	178	184	191	175
findindex	20	19	19	20	18	17	16	23	16	22	12	15
findindices	24	20	28	23	27	23	25	22	26	21	30	30
repeat	124	128	127	121	112	42	102	36	93	34	112	106
takewhile	249	227	239	241	228	188	168	125	162	153	268	175
add	99	138	93	114	76	105	41	38	46	40	115	43
truediv	67	62	70	73	71	67	58	52	51	46	116	65
floordiv	32	36	33	37	35	35	32	33	28	26	142	70
mod	24	29	21	30	26	25	30	21	32	22	76	54
mul	19	29	14	22	8.6	67	4.9	34	4.9	33	113	44
neg	136		125		120		65		103		128	74
pow	61	52	52	52	42	60	22	50	22	56	8.2	12
sub	92	163	94	131	85	147	56	51	63	50	133	46
and_	183	167	233	158	165	153	52	44	51	40		
or_	208	198	242	185	165	139	55	47	67	35		
xor	174	181	251	177	140	126	51	46	55	46		
invert	366	297	349	337	300	287	117	162	129	155		
eq	150	102	99	87	126	146	63	74	66	70	100	61
gt	99	111	154	111	116	102	71	87	78	66	88	56
ge	146	108	98	99	98	109	67	71	74	73	138	67
lt	99	95	93	138	156	94	71	89	80	73	108	72
le	143	106	93	94	97	103	72	75	69	72	131	69

ne	100	102	170	123	157	174	83	96	89	89	98	73
lshift	177	237	174	236	162	173	56	46	64	59		
rshift	194	200	194	190	207	140	57	46	58	50		
abs_	127		119		94		72		58		155	80
acos											15	11
acosh											10	6.1
asin											16	9.4
asinh											6.5	6.3
atan											14	10
atan2											10	8.1
atanh											6.9	7.4
ceil											225	183
copysign											209	77
cos											15	6.3
cosh											12	7.8
degrees											152	121
erf											17	12
erfc											11	7.5
exp											22	8.4
expm1											7.8	7.4
fabs											270	152
factorial	196	229	196	225	186	191	103	83	99	83		
floor											228	148
fma											118	41
fmod											12	11
gamma											1.6	1.3
hypot											25	14
isfinite											132	114
isinf											140	111
isnan											184	141
ldexp											32	27
lgamma											11	6.4
log											32	7.9
log10											15	6.7
log1p											7.9	9.9
log2											24	10
radians											168	84
sin											17	7.5

sinh											5.9	5.2
sqrt											44	35
tan											6.5	5.0
tanh											5.9	5.9
trunc											261	153

Stat	Value
Average:	82
Maximum:	366
Minimum:	1.3
Array size:	100000

Optmised Performance (No SIMD)

In this set of tests, all arithmatic error checking was disabled (not the default state) and SIMD acceleration was also disabled (not the normal default).

function	b	B	h	H	i	I	l	L	q	Q	f	d
aall	7.5	8.2	9.8	7.7	8.4	9.4	7.6	9.9	6.6	11	13	11
aany	5.0	5.6	4.1	4.2	4.7	5.1	4.4	5.7	4.5	5.6	11	6.3
afilter	128	120	120	119	115	102	131	130	126	121	129	121
amax	26	21	23	20	21	23	14	15	15	17	21	21
amin	21	19	24	20	24	20	15	16	14	15	32	32
asum	13	15	13	15	12	16	13	15	13	15	6.2	6.0
compress	33	34	37	22	29	17	34	24	37	20	32	29
count	199	209	147	192	139	107	99	112	116	103	76	75
cycle	87	89	87	88	84	63	83	54	86	60	58	58
dropwhile	235	238	222	213	187	194	193	190	188	195	196	179
findindex	20	20	20	21	16	17	16	22	16	21	12	17
findindices	26	21	27	22	25	22	27	23	26	21	28	28
repeat	128	125	125	116	116	40	121	38	119	39	112	104
takewhile	254	213	233	229	246	209	201	154	184	160	243	184
add	264	237	259	242	168	180	138	92	153	92	224	114
truediv	67	59	60	66	71	68	64	58	59	49	183	151
floordiv	37	32	39	35	36	29	35	29	35	26	182	150
mod	24	26	21	30	28	27	29	24	30	25	102	84
mul	161	159	173	157	167	131	83	86	82	66	170	94
neg	135		185		156		70		84		179	92
pow	51	47	41	44	29	48	15	45	15	59	7.5	14
sub	158	159	158	141	148	173	106	100	109	90	222	100
and_	257	241	273	163	250	245	148	98	104	100		

or_	303	294	289	206	263	225	165	123	158	97		
xor	246	264	245	178	220	203	105	92	137	103		
invert	338	278	328	309	296	264	120	163	143	166		
eq	83	87	85	80	84	120	87	125	92	93	107	99
gt	78	121	98	78	113	111	100	166	119	125	141	93
ge	103	91	98	98	88	140	103	133	94	120	116	149
lt	117	110	115	82	102	113	124	148	141	128	122	109
le	101	127	98	99	91	125	121	113	125	121	125	108
ne	121	120	143	81	151	117	134	173	155	142	108	102
lshift	223	289	211	252	184	205	112	100	111	102		
rshift	200	202	209	199	284	166	132	99	135	103		
abs_	130		136		133		77		82		161	78
acos											16	11
acosh											11	6.3
asin											17	10.0
asinh											6.8	6.5
atan											16	11
atan2											9.6	6.1
atanh											7.4	7.7
ceil											248	293
copysign											282	167
cos											15	6.1
cosh											13	8.0
degrees											221	137
erf											17	12
erfc											11	7.5
exp											24	8.5
expm1											8.2	7.5
fabs											300	177
factorial	178	185	138	179	180	156	111	88	123	90		
floor											361	143
fma											147	40
fmod											14	13
gamma											1.5	1.3
hypot											29	14
isfinite											134	99
isinf											141	115
isnan											185	150

ldexp											35	34
lgamma											10	6.4
log											32	7.9
log10											16	6.8
log1p											8.3	10
log2											26	11
radians											185	118
sin											17	7.4
sinh											5.8	5.5
sqrt											49	34
tan											6.9	5.1
tanh											6.1	6.2
trunc											426	158

Stat	Value
Average:	98
Maximum:	426
Minimum:	1.3
Array size:	100000

Optmised Performance (with SIMD)

In this set of tests, all arithmatic error checking was disabled (not the default state) and SIMD acceleration was enabled (the normal default).

Relative Performance with SIMD Optimisations - Python Time / Arrayfunc Time.

function	b	B	h	H	i	I	l	L	q	Q	f	d
aall	101	109	53	46	23	29	8.4	12	8.9	12	44	22
aany	63	51	33	30	15	18	4.5	6.3	3.8	5.9	20	10
afilter	120	122	127	125	119	103	125	124	124	122	131	118
amax	81	80	41	40	75	111	14	15	15	17	111	62
amin	77	76	39	39	111	81	15	16	15	14	104	38
asum	13	15	13	14	12	15	13	14	13	15	23	11
compress	36	36	40	24	30	17	39	29	40	25	32	31
count	199	206	142	210	150	113	111	111	104	93	78	82
cycle	88	88	78	88	85	65	90	59	89	55	52	55
dropwhile	227	223	226	221	194	202	191	183	180	181	192	179
findindex	200	195	89	87	56	56	16	22	17	23	65	32
findindices	26	21	28	23	27	23	27	23	26	22	29	28
repeat	127	135	129	118	123	42	126	39	116	38	115	97
takewhile	257	232	253	257	232	185	152	144	187	150	279	178

add	1538	1395	970	906	427	346	112	85	123	107	450	168
truediv	66	57	61	68	72	66	63	61	64	54	182	150
floordiv	37	32	39	35	36	29	36	28	35	27	183	151
mod	25	27	21	33	33	30	32	25	31	29	117	105
mul	1200	1053	817	704	405	348	82	80	84	69	520	196
neg	1065		646		383		67		89		178	86
pow	50	47	41	43	29	49	15	45	16	58	7.6	14
sub	1475	1484	955	868	415	340	96	85	127	93	419	130
and_	2241	2061	923	791	429	404	156	153	119	116		
or_	2275	2154	1055	1072	514	475	166	143	162	104		
xor	2020	2130	881	951	430	410	105	104	104	104		
invert	2664	3213	1342	1734	670	846	138	160	141	200		
eq	1082	1237	563	580	300	324	90	128	91	88	324	183
gt	1251	1574	733	574	388	403	112	161	126	100	316	150
ge	1066	1189	555	552	310	319	107	132	103	100	384	180
lt	1041	1303	752	629	423	417	125	148	145	137	361	191
le	1121	1223	554	539	342	344	112	101	124	117	324	167
ne	1128	1296	620	603	380	398	128	168	152	135	315	173
lshift	208	269	212	254	187	207	93	102	107	90		
rshift	204	202	208	200	288	160	127	96	131	96		
abs_	1366		924		329		79		85		163	82
acos											16	11
acosh											11	6.3
asin											17	9.9
asinh											6.5	6.6
atan											16	11
atan2											9.9	6.4
atanh											7.3	7.7

ceil											872	307
copysign											284	167
cos											15	6.3
cosh											13	8.0
degrees											549	183
erf											18	14
erfc											11	7.6
exp											24	8.7
expm1											7.8	7.1
fabs											291	184
factorial	171	180	142	181	181	152	108	99	108	95		
floor											628	238
fma											145	41
fmod											13	13
gamma											1.6	1.3
hypot											29	14
isfinite											121	111
isinf											138	115
isnan											196	148
ldexp											37	36
lgamma											10	6.1
log											32	7.9
log10											16	7.0
log1p											8.3	11
log2											27	12
radians											495	154
sin											17	7.5
sinh											6.0	5.5
sqrt											208	82
tan											6.3	5.0
tanh											6.1	6.1
trunc											729	200

Stat	Value
Average:	245
Maximum:	3213
Minimum:	1.3
Array size:	100000

Math Error Disable Optimisation Effects

This set of tests shows what the performance effects of disabling math error checking are for those functions which support it. Note that very small deviations may reflect benchmark timing errors rather than actual differences.

The most notable point is that in many cases there is little or nothing to be gained in terms of performance by disabling error checking.

Some compilers may generate SIMD optimisations automatically, skewing the apparent results.

Relative Performance with and without math Optimisations - Unoptimsed / Optimised Time.

function	b	B	h	H	i	I	l	L	q	Q	f	d
asum	1.6	1.6	1.6	1.6	1.6	1.7	1.6	1.7	1.6	1.7	1.0	1.0
add	2.7	1.7	2.8	2.1	2.2	1.7	3.3	2.5	3.4	2.3	1.9	2.6
truediv	1.0	1.0	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.1	1.6	2.3
floordiv	1.1	0.9	1.2	0.9	1.0	0.8	1.1	0.9	1.2	1.0	1.3	2.2
mod	1.0	0.9	1.0	1.0	1.1	1.1	1.0	1.1	0.9	1.1	1.3	1.6
mul	8.6	5.5	12	7.3	20	2.0	17	2.5	17	2.0	1.5	2.2
neg	1.0		1.5		1.3		1.1		0.8		1.4	1.2
pow	0.8	0.9	0.8	0.9	0.7	0.8	0.7	0.9	0.7	1.0	0.9	1.1
sub	1.7	1.0	1.7	1.1	1.7	1.2	1.9	1.9	1.7	1.8	1.7	2.2
abs_	1.0		1.1		1.4		1.1		1.4		1.0	1.0
acos											1.0	1.0
acosh											1.1	1.0
asin											1.1	1.1
asinh											1.0	1.0
atan											1.1	1.0
atan2											0.9	0.8
atanh											1.1	1.0
ceil											1.1	1.6
copysign											1.4	2.2
cos											1.0	1.0
cosh											1.1	1.0
degrees											1.5	1.1
erf											1.0	1.0
erfc											1.0	1.0
exp											1.1	1.0
expm1											1.1	1.0
fabs											1.1	1.2
factorial	0.9	0.8	0.7	0.8	1.0	0.8	1.1	1.1	1.2	1.1		
floor											1.6	1.0
fma											1.2	1.0

fmod											1.1	1.2
gamma											1.0	1.0
hypot											1.1	0.9
ldexp											1.1	1.3
lgamma											0.9	1.0
log											1.0	1.0
log10											1.1	1.0
log1p											1.1	1.0
log2											1.1	1.1
radians											1.1	1.4
sin											1.0	1.0
sinh											1.0	1.1
sqrt											1.1	1.0
tan											1.1	1.0
tanh											1.0	1.0
trunc											1.6	1.0

SIMD Optimisation Effects

This set of tests shows what the effect of SIMD optimisations are for those functions which support it. SIMD optimisations are enabled by default except in a few cases where they conflict with math error checking (in which case error checking must be disabled to use them). This information may be useful in deciding which platform you wish to use to run your application.

Relative Performance with and without SIMD Optimisations - Unoptimsed / Optimised Time.

function	b	B	h	H	i	I	l	L	q	Q	f	d
aall	13	13	5.4	6.0	2.8	3.1					3.4	1.9
aany	13	9.1	8.0	7.1	3.2	3.6					1.8	1.6
amax	3.1	3.7	1.8	2.0	3.6	4.9					5.3	2.9
amin	3.6	4.0	1.6	2.0	4.7	4.1					3.3	1.2
asum											3.7	1.9
findindex	10	9.9	4.4	4.2	3.5	3.2					5.6	1.9
add	5.8	5.9	3.7	3.7	2.5	1.9					2.0	1.5
mul	7.5	6.6	4.7	4.5	2.4	2.6					3.1	2.1
neg	7.9		3.5		2.4							
sub	9.4	9.3	6.0	6.1	2.8	2.0					1.9	1.3
and_	8.7	8.6	3.4	4.9	1.7	1.6						
or_	7.5	7.3	3.6	5.2	2.0	2.1						
xor	8.2	8.1	3.6	5.4	2.0	2.0						
invert	7.9	12	4.1	5.6	2.3	3.2						
eq	13	14	6.6	7.2	3.6	2.7					3.0	1.8

gt	16	13	7.5	7.4	3.4	3.6					2.2	1.6
ge	10	13	5.7	5.6	3.5	2.3					3.3	1.2
lt	8.9	12	6.5	7.7	4.1	3.7					3.0	1.7
le	11	9.6	5.6	5.5	3.7	2.8					2.6	1.5
ne	9.4	11	4.3	7.5	2.5	3.4					2.9	1.7
abs_	10		6.8		2.5							
ceil											3.5	1.0
degrees											2.5	1.3
floor											1.7	1.7
radians											2.7	1.3
sqrt											4.2	2.4
trunc											1.7	1.3

Array Size Versus Performance

The following shoes the effects of array size on a selected arrayfunc function benchmark.

As array size increases, function call overhead decreases as a proportion of total run time.

Declines in performance when the array exceeds a certain size may be related to hardware cache effects. Arrayfunc functions together with their data may be able to reside entirely in cache, but larger arrays may require repeated cache reloads. This threshold will depend upon the particular hardware being used.

Add two arrays - times faster than Python, unoptimised.

Array size	b	B	h	H	i	I	l	L	q	Q	f	d
10	2.2	1.6	1.7	1.5	1.6	1.3	1.6	1.1	1.5	1.1	1.3	1.3
100	13	11	12	10	12	8.5	11	8.4	10	8.5	9.6	9.8
1000	56	65	58	60	45	49	45	45	43	45	51	49
10000	89	124	91	110	72	102	73	87	72	91	109	103
100000	95	140	96	117	79	118	53	50	57	55	124	63
1000000	81	123	90	107	72	76	50	43	51	42	88	49
10000000	92	132	89	112	83	80	54	16	19	30	88	50

Add constant to array - times faster than Python, optimised.

Array size	b	B	h	H	i	I	l	L	q	Q	f	d
10	1.4	1.1	1.2	1.1	1.2	1.0	1.2	0.9	1.1	0.9	1.0	1.0
100	10	8.8	10.0	8.2	9.8	7.0	9.2	6.7	9.1	7.1	8.1	8.1
1000	92	84	91	77	67	60	58	41	54	42	67	52
10000	580	517	486	439	299	230	157	109	158	105	280	175
100000	1525	1423	967	899	443	345	134	79	125	86	426	122
1000000	835	737	248	243	124	110	68	53	67	54	127	65
10000000	530	459	260	222	129	78	66	31	53	55	119	68

Platform Effects

The platform, including CPU, OS, compiler, and compiler version can affect performance, and this influence can change significantly for different functions.

If your application requires exact performance data, then benchmark your application in the specific platform (hardware, OS, and compiler) that you will be using.

Platform support

Arrayfunc is written in 'C' and uses the standard C libraries to implement the underlying math functions. Arrayfunc has been tested on the following platforms.

OS	Bits	Compiler	Python Version Tested
Ubuntu 18.04 LTS	64 bit	GCC	3.6
Ubuntu 19.04	64 bit	GCC	3.7
Debian 10	32 bit	GCC	3.6
Debian 10	64 bit	GCC	3.6
OpenSuse 15	64 bit	GCC	3.6
Centos 7	64 bit	GCC	3.6
FreeBSD 12	64 bit	LLVM	3.6
MS Windows 10	64 bit	MS Visual Studio C 2015	3.7
Raspbian (RPi 3)	32 bit	GCC	3.5

The Raspbian (RPi 3) tests were conducted on a Raspberry Pi ARM CPU. All others were conducted using VMs running on x86 hardware.