# The GCC Quad-Precision Math Library

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# Introduction

This manual documents the usage of libquadmath, the GCC Quad-Precision Math Library Application Programming Interface (API).

# 1 Typedef and constants

The following data type has been defined via `typedef`.

`__complex128`: `__float128`-based complex number

The following macros are defined, which give the numeric limits of the `__float128` data type.

`FLT128_MAX`: largest finite number
`FLT128_MIN`: smallest positive number with full precision
`FLT128_EPSILON`: difference between 1 and the next larger representable number

`FLT128_DENORM_MIN`: smallest positive denormalized number
`FLT128_MANT_DIG`: number of digits in the mantissa (bit precision)
`FLT128_MIN_EXP`: maximal negative exponent
`FLT128_MAX_EXP`: maximal positive exponent
`FLT128_DIG`: number of decimal digits in the mantissa
`FLT128_MIN_10_EXP`: maximal negative decimal exponent
`FLT128_MAX_10_EXP`: maximal positive decimal exponent

The following mathematical constants of type `__float128` are defined.

`M_Eq`: the constant e (Euler's number)
`M_LOG2Eq`: binary logarithm of 2
`M_LOG10Eq`: common, decimal logarithm of 2
`M_LN2q`: natural logarithm of 2
`M_LN10q`: natural logarithm of 10
`M_PIq`: pi

`M_PI_2q`: two pi
`M_PI_4q`: four pi
`M_1_PIq`: one over pi
`M_2_PIq`: one over two pi
`M_2_SQRTPIq`: two over square root of pi
`M_SQRT2q`: square root of 2
`M_SQRT1_2q`: one over square root of 2

# 2 Math Library Routines

The following mathematical functions are available:

`acosq`: arc cosine function
`acoshq`: inverse hyperbolic cosine function
`asinq`: arc sine function
`asinhq`: inverse hyperbolic sine function
`atanq`: arc tangent function
`atanhq`: inverse hyperbolic tangent function
`atan2q`: arc tangent function
`cbrtq`: cube root function
`ceilq`: ceiling value function
`copysignq`: copy sign of a number
`coshq`: hyperbolic cosine function
`cosq`: cosine function
`erfq`: error function
`erfcq`: complementary error function
`expq`: exponential function
`expm1q`: exponential minus 1 function

`fabsq`: absolute value function
`fdimq`: positive difference function
`finiteq`: check finiteness of value
`floorq`: floor value function
`fmaq`: fused multiply and add
`fmaxq`: determine maximum of two values
`fminq`: determine minimum of two values
`fmodq`: remainder value function
`frexpq`: extract mantissa and exponent
`hypotq`: Eucledian distance function
`ilogbq`: get exponent of the value
`isinfq`: check for infinity
`isnanq`: check for not a number
`j0q`: Bessel function of the first kind, first order
`j1q`: Bessel function of the first kind, second order
`jnq`: Bessel function of the first kind, $n$-th order
`ldexpq`: load exponent of the value
`lgammaq`: logarithmic gamma function
`llrintq`: round to nearest integer value
`llroundq`: round to nearest integer value away from zero
`logq`: natural logarithm function
`log10q`: base 10 logarithm function
`log1pq`: compute natural logarithm of the value plus one
`log2q`: base 2 logarithm function

`lrintq`: round to nearest integer value
`lroundq`: round to nearest integer value away from zero
`modfq`: decompose the floating-point number
`nanq`: return quiet NaN
`nearbyintq`: round to nearest integer
`nextafterq`: next representable floating-point number
`powq`: power function
`remainderq`: remainder function
`remquoq`: remainder and part of quotient
`rintq`: round-to-nearest integral value
`roundq`: round-to-nearest integral value, return `__float128`
`scalblnq`: compute exponent using `FLT_RADIX`
`scalbnq`: compute exponent using `FLT_RADIX`
`signbitq`: return sign bit
`sincosq`: calculate sine and cosine simulataneously
`sinhq`: hyperbolic sine function
`sinq`: sine function
`sqrtq`: square root function
`tanq`: tangent function
`tanhq`: hyperbolic tangent function
`tgammaq`: true gamma function
`truncq`: round to integer, towards zero
`y0q`: Bessel function of the second kind, first order
`y1q`: Bessel function of the second kind, second order
`ynq`: Bessel function of the second kind, *n*-th order
`cabsq` complex absolute value function
`cargq`: calculate the argument
`cimagq` imaginary part of complex number
`crealq`: real part of complex number
`cacoshq`: complex arc hyperbolic cosine function
`cacosq`: complex arc cosine function
`casinhq`: complex arc hyperbolic sine function
`casinq`: complex arc sine function
`catanhq`: complex arc hyperbolic tangent function
`catanq`: complex arc tangent function
`ccosq` complex cosine function:
`ccoshq`: complex hyperbolic cosine function
`cexpq`: complex exponential function
`cexpiq`: computes the exponential function of "i" times a real value

`clogq`: complex natural logarithm
`clog10q`: complex base 10 logarithm
`conjq`: complex conjugate function
`cpowq`: complex power function
`cprojq`: project into Riemann Sphere
`csinq`: complex sine function
`csinhq`: complex hyperbolic sine function
`csqrtq`: complex square root
`ctanq`: complex tangent function
`ctanhq`: complex hyperbolic tangent function

# 3 I/O Library Routines

## 3.1 strtoflt128 — Convert from string

The function dmath_strtopQ converts a string into a __float128 number.

Syntax `__float128 strtoflt128 (const char *s, char **sp)`

*Arguments*:

| | |
|---|---|
| *s* | input string |
| *sp* | the address of the next character in the string |

The argument *sp* contains, if not NULL, the address of the next character following the parts of the string, which have been read.

Example

```
#include <quadmath.h>

int main ()
{
  __float128 r;

  r = strtoflt128 ("1.2345678", NULL);

  return 0;
}
```

## 3.2 quadmath_snprintf — Convert to string

The function quadmath_snprintf converts a __float128 floating-point number into a string. It is a specialized alternative to snprintf, where the format string is restricted to a single conversion specifier with Q modifier and conversion specifier e, E, f, F, g, G, a or A, with no extra characters before or after the conversion specifier. The %m$ or *m$ style must not be used in the format.

Syntax `int quadmath_snprintf (char *s, size_t size, const char *format, ...)`

*Arguments*:

| | |
|---|---|
| *s* | output string |
| *size* | byte size of the string, including tailing NUL |
| *format* | conversion specifier string |

Example

```
#include <quadmath.h>
#include <stdlib.h>
#include <stdio.h>

int main ()
{
  __float128 r;
  int prec = 20;
  int width = 46;
  char buf[128];
```

```
  r = 2.0q;
  r = sqrtq (r);
  int n = quadmath_snprintf (buf, sizeof buf, "%+-#*.20Qe", width, r);
  if ((size_t) n < sizeof buf)
    printf ("%s\n", buf);
    /* Prints: +1.41421356237309504880e+00 */
  quadmath_snprintf (buf, sizeof buf, "%Qa", r);
  if ((size_t) n < sizeof buf)
    printf ("%s\n", buf);
    /* Prints: 0x1.6a09e667f3bcc908b2fb1366ea96p+0 */
  n = quadmath_snprintf (NULL, 0, "%+-#46.*Qe", prec, r);
  if (n > -1)
    {
      char *str = malloc (n + 1);
      if (str)
        {
          quadmath_snprintf (str, n + 1, "%+-#46.*Qe", prec, r);
          printf ("%s\n", str);
          /* Prints: +1.41421356237309504880e+00 */
        }
      free (str);
    }
  return 0;
}
```

On some targets when supported by the C library hooks are installed for `printf` family of functions, so that `printf ("%Qe", 1.2Q);` etc. works too.

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