

IEC 60559 MATH FUNCTIONS FOR C2X

N2373

WG 14 - London

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C FP group

Proposal for C2x

- N2355
- Add ISO/IEC TS 18661-4 math functions to C2X
- In `<math.h>` and `<tgmath.h>`
- Specified in IEC 60559-2008, updated in IEEE 754-2019
- TS 18661-4 reduction functions not included

TS 18661-4a math functions

- IEC 60559 specifies a set of 39 optional mathematical operations
- C `<math.h>` already supports 22 of them
- This proposal adds functions for the rest
- Does not require IEC 60559-specified correct rounding
- Names with `cr` prefixes reserved for correctly rounded versions, e.g., `crsin` for correctly rounded sin function

IEC 60559 math operation	Current C function	Proposed C function
exp	exp	
expm1	expm1	
exp2	exp2	
exp2m1		exp2m1
exp10		exp10
exp10m1		exp10m1
log	log	
log2	log2	
log10	log10	
logp1	log1p	logp1
log2p1		log2p1
log10p1		log10p1
hypot	hypot	
rSqrt		rsqrt
compound		compoundn
rootn		rootn
pown		pown
pow	pow	
powr		powr
sin	sin	
cos	cos	
tan	tan	
sinPi		sinpi
cosPi		cospi
tanPi		tanpi
asinPi		asinpi
acosPi		acospi
atanPi		atanpi
atan2Pi		atan2pi
asin	asin	
acos	acos	
atan	atan	
atan2	atan2	
sinh	sinh	
cosh	cosh	
tanh	tanh	
asinh	asinh	
acosh	acosh	
atanh	atanh	

Exponential and logarithmic functions

Complete the set of exponential and logarithmic functions already in \mathbb{C} , for bases e , 2 , and 10 :

$$\mathbf{exp10}(x) = 10^x$$

$$\mathbf{exp2m1}(x) = 2^x - 1$$

$$\mathbf{exp10m1}(x) = 10^x - 1$$

$$\mathbf{log2p1}(x) = \log_2(x + 1)$$

$$\mathbf{log10p1}(x) = \log_{10}(x + 1)$$

$$\mathbf{logp1}(x) = \log_e(x + 1), \text{ alternate name for existing } \log_1 p$$

Power functions

Add variations on C pow function, for better performance and accuracy and simpler behavior in common applications :

rsqrt(x) = $1/\sqrt{x}$ – common graphics primitive

compound(x, n) = $(1 + x)^n$, for int n – for finance and growth/decay applications, more accurate than pow(1+x,n), particularly for small x

rootn(x, n) = $x^{1/n}$, for int n – alternative to **pow**(x, 1.0/n)

pown(x, n) = x^n , for int n

powr(x, y) = x^y , for x in $[0, +\infty]$ – models continuous power function

For detailed rationale, see

<http://754r.ucbtest.org/background/power.txt>

Pi trig functions

Add pi (half-revolution) trig functions, to avoid roundoff errors at multiples of π and allow faster argument reduction:

$$\mathbf{asinpi}(x) = \arcsin(x) / \pi$$

$$\mathbf{acospi}(x) = \arccos(x) / \pi$$

$$\mathbf{atanpi}(x) = \arctan(x) / \pi$$

$$\mathbf{atan2pi}(y, x) = \arctan(y/x) / \pi$$

$$\mathbf{sinpi}(x) = \sin(\pi \times x)$$

$$\mathbf{cospi}(x) = \cos(\pi \times x)$$

$$\mathbf{tanpi}(x) = \tan(\pi \times x)$$

Optional?

Why are these mathematical operations *recommended* but not *required* in IEC 60559?

IEC 60559 allows for a wide range of implementations, including minimal ones for special purposes. Thus it recommends but does not require support for features not needed by minimal implementations, however important for language standards like C for general purpose implementations. For example, it does not require support for more than one floating-point format or the recommended mathematical operations.

For more explanation, see

<http://754r.ucbtest.org/background/conformance-and-options.txt>

Implementation

- Intel: exp10, powr, all the *pi functions, compound
- Sun Solaris: all the *pi and {log,exp}{2,10}* functions
- HP: exp10, rsqrt, compound
- Microsoft, Khronos: *pi functions
- GCC, Microsoft: exp10
- Microsoft: rsqrt

Publication

- [ISO/IEC TS 18661-4:2015, Information Technology — Programming languages, their environments, and system software interfaces — Floating-point extensions for C — Part 4: Supplementary functions](#)