



# CUDA MATH API

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## API Reference Manual



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# Chapter 1.

## MODULES

Here is a list of all modules:

- ▶ Half Precision Intrinsics
  - ▶ Half Arithmetic Functions
  - ▶ Half2 Arithmetic Functions
  - ▶ Half Comparison Functions
  - ▶ Half2 Comparison Functions
  - ▶ Half Precision Conversion And Data Movement
  - ▶ Half Math Functions
  - ▶ Half2 Math Functions
- ▶ Mathematical Functions
- ▶ Single Precision Mathematical Functions
- ▶ Double Precision Mathematical Functions
- ▶ Single Precision Intrinsics
- ▶ Double Precision Intrinsics
- ▶ Integer Intrinsics
- ▶ Type Casting Intrinsics
- ▶ SIMD Intrinsics

### 1.1. Half Precision Intrinsics

This section describes half precision intrinsic functions that are only supported in device code. To use these functions include the header file `cuda_fp16.h` in your program.

#### Half Arithmetic Functions

#### Half2 Arithmetic Functions

## Half Comparison Functions

## Half2 Comparison Functions

## Half Precision Conversion And Data Movement

## Half Math Functions

## Half2 Math Functions

### 1.1.1. Half Arithmetic Functions

#### Half Precision Intrinsics

To use these functions include the header file `cuda_fp16.h` in your program.

**`__device__ __half2 __h2div (const __half2 a, const __half2 b)`**

Performs `half2` vector division in round-to-nearest-even mode.

#### Parameters

**a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

#### Returns

`half2`

- The  
elementwise division of `a` with `b`.

#### Description

Divides `half2` input vector `a` by input vector `b` in round-to-nearest mode.

DEEPLearn-SRM\_REQ-103

**\_\_device\_\_ \_\_half \_\_hadd (const \_\_half a, const \_\_half b)**

Performs `half` addition in round-to-nearest-even mode.

### Parameters

- a**  
- `half`. Is only being read.
- b**  
- `half`. Is only being read.

### Returns

`half`

- The  
sum of `a` and `b`.

### Description

Performs `half` addition of inputs `a` and `b`, in round-to-nearest-even mode.

DEEPLearn-SRM\_REQ-94

**\_\_device\_\_ \_\_half \_\_hadd\_sat (const \_\_half a, const \_\_half b)**

Performs `half` addition in round-to-nearest-even mode, with saturation to `[0.0, 1.0]`.

### Parameters

- a**  
- `half`. Is only being read.
- b**  
- `half`. Is only being read.

### Returns

`half`

- The  
sum of `a` and `b`, with respect to saturation.

### Description

Performs `half` add of inputs `a` and `b`, in round-to-nearest-even mode, and clamps the result to range `[0.0, 1.0]`. NaN results are flushed to `+0.0`. TBR

**`__device__ __half __hdiv (const __half a, const __half b)`**

Performs `half` division in round-to-nearest-even mode.

### Parameters

- a**  
- `half`. Is only being read.
- b**  
- `half`. Is only being read.

### Returns

`half`

- The  
result of dividing `a` by `b`.

### Description

Divides `half` input `a` by input `b` in round-to-nearest mode. DEEPLearn-SRM\_REQ-98

**`__device__ __half __hfma (const __half a, const __half b, const __half c)`**

Performs `half` fused multiply-add in round-to-nearest-even mode.

### Parameters

- a**  
- `half`. Is only being read.
- b**  
- `half`. Is only being read.
- c**  
- `half`. Is only being read.

### Returns

`half`

- The  
result of fused multiply-add operation on `a`, `b`, and `c`.

### Description

Performs `half` multiply on inputs `a` and `b`, then performs a `half` add of the result with `c`, rounding the result once in round-to-nearest-even mode. DEEPLearn-SRM\_REQ-96

**\_\_device\_\_ \_\_half \_\_hfma\_sat (const \_\_half a, const \_\_half b, const \_\_half c)**

Performs `half` fused multiply-add in round-to-nearest-even mode, with saturation to `[0.0, 1.0]`.

### Parameters

- a**  
- `half`. Is only being read.
- b**  
- `half`. Is only being read.
- c**  
- `half`. Is only being read.

### Returns

`half`

- The  
result of fused multiply-add operation on `a`, `b`, and `c`, with respect to saturation.

### Description

Performs `half` multiply on inputs `a` and `b`, then performs a `half` add of the result with `c`, rounding the result once in round-to-nearest-even mode, and clamps the result to range `[0.0, 1.0]`. NaN results are flushed to `+0.0`. TBR

**\_\_device\_\_ \_\_half \_\_hmul (const \_\_half a, const \_\_half b)**

Performs `half` multiplication in round-to-nearest-even mode.

### Parameters

- a**  
- `half`. Is only being read.
- b**  
- `half`. Is only being read.

### Returns

`half`

- The  
result of multiplying `a` and `b`.

**Description**

Performs `half` multiplication of inputs `a` and `b`, in round-to-nearest mode.  
DEEPLearn-SRM\_REQ-99

`__device__ __half __hmul_sat (const __half a, const __half b)`

Performs `half` multiplication in round-to-nearest-even mode, with saturation to `[0.0, 1.0]`.

**Parameters**

**a**

- `half`. Is only being read.

**b**

- `half`. Is only being read.

**Returns**

`half`

- The result of multiplying `a` and `b`, with respect to saturation.

**Description**

Performs `half` multiplication of inputs `a` and `b`, in round-to-nearest mode, and clamps the result to range `[0.0, 1.0]`. NaN results are flushed to `+0.0`. TBR

`__device__ __half __hneg (const __half a)`

Negates input `half` number and returns the result.

**Parameters**

**a**

- `half`. Is only being read.

**Returns**

`half`

- minus `a`

**Description**

Negates input `half` number and returns the result. DEEPLearn-SRM\_REQ-100

**\_\_device\_\_ \_\_half \_\_hsub (const \_\_half a, const \_\_half b)**

Performs `half` subtraction in round-to-nearest-even mode.

### Parameters

**a**

- `half`. Is only being read.

**b**

- `half`. Is only being read.

### Returns

`half`

► The

result of subtracting `b` from `a`.

### Description

Subtracts `half` input `b` from input `a` in round-to-nearest mode. DEEPLearn-SRM\_REQ-97

**\_\_device\_\_ \_\_half \_\_hsub\_sat (const \_\_half a, const \_\_half b)**

Performs `half` subtraction in round-to-nearest-even mode, with saturation to `[0.0, 1.0]`.

### Parameters

**a**

- `half`. Is only being read.

**b**

- `half`. Is only being read.

### Returns

`half`

► The

result of subtraction of `b` from `a`, with respect to saturation.

### Description

Subtracts `half` input `b` from input `a` in round-to-nearest mode, and clamps the result to range `[0.0, 1.0]`. NaN results are flushed to `+0.0`. TBR

## 1.1.2. Half2 Arithmetic Functions

### Half Precision Intrinsics

To use these functions include the header file `cuda_fp16.h` in your program.

**`__device__ __half2 __hadd2 (const __half2 a, const __half2 b)`**

Performs `half2` vector addition in round-to-nearest-even mode.

#### Parameters

**a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

#### Returns

`half2`

► The

sum of vectors `a` and `b`.

#### Description

Performs `half2` vector add of inputs `a` and `b`, in round-to-nearest mode. DEEPLearn-SRM\_REQ-95

**`__device__ __half2 __hadd2_sat (const __half2 a, const __half2 b)`**

Performs `half2` vector addition in round-to-nearest-even mode, with saturation to `[0.0, 1.0]`.

#### Parameters

**a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

#### Returns

`half2`

► The

sum of `a` and `b`, with respect to saturation.



**Description**

Performs `half2` vector add of inputs `a` and `b`, in round-to-nearest mode, and clamps the results to range `[0.0, 1.0]`. NaN results are flushed to `+0.0`. TBR

`__device__ __half2 __hfma2 (const __half2 a, const __half2 b, const __half2 c)`

Performs `half2` vector fused multiply-add in round-to-nearest-even mode.

**Parameters**

- a**  
- `half2`. Is only being read.
- b**  
- `half2`. Is only being read.
- c**  
- `half2`. Is only being read.

**Returns**

`half2`

- The  
result of elementwise fused multiply-add operation on vectors `a`, `b`, and `c`.

**Description**

Performs `half2` vector multiply on inputs `a` and `b`, then performs a `half2` vector add of the result with `c`, rounding the result once in round-to-nearest-even mode. DEEPLearn-SRM\_REQ-105

`__device__ __half2 __hfma2_sat (const __half2 a, const __half2 b, const __half2 c)`

Performs `half2` vector fused multiply-add in round-to-nearest-even mode, with saturation to `[0.0, 1.0]`.

**Parameters**

- a**  
- `half2`. Is only being read.
- b**  
- `half2`. Is only being read.
- c**  
- `half2`. Is only being read.

**Returns**

half2

- The result of elementwise fused multiply-add operation on vectors `a`, `b`, and `c`, with respect to saturation.

**Description**

Performs `half2` vector multiply on inputs `a` and `b`, then performs a `half2` vector add of the result with `c`, rounding the result once in round-to-nearest-even mode, and clamps the results to range `[0.0, 1.0]`. NaN results are flushed to `+0.0`. TBR

`__device__ __half2 __hmul2 (const __half2 a, const __half2 b)`

Performs `half2` vector multiplication in round-to-nearest-even mode.

**Parameters**

- a**  
- `half2`. Is only being read.
- b**  
- `half2`. Is only being read.

**Returns**

half2

- The result of elementwise multiplying the vectors `a` and `b`.

**Description**

Performs `half2` vector multiplication of inputs `a` and `b`, in round-to-nearest-even mode. DEEPLearn-SRM\_REQ-102

`__device__ __half2 __hmul2_sat (const __half2 a, const __half2 b)`

Performs `half2` vector multiplication in round-to-nearest-even mode, with saturation to `[0.0, 1.0]`.

**Parameters**

- a**  
- `half2`. Is only being read.
- b**  
- `half2`. Is only being read.

**Returns**

half2

- The  
result of elementwise multiplication of vectors `a` and `b`, with respect to saturation.

**Description**

Performs `half2` vector multiplication of inputs `a` and `b`, in round-to-nearest-even mode, and clamps the results to range `[0.0, 1.0]`. NaN results are flushed to `+0.0`. TBR

**\_\_device\_\_ \_\_half2 \_\_hneg2 (const \_\_half2 a)**

Negates both halves of the input `half2` number and returns the result.

**Parameters**

- a**  
- `half2`. Is only being read.

**Returns**

half2

- Returns  
`a` with both halves negated.

**Description**

Negates both halves of the input `half2` number `a` and returns the result. DEEPLearn-SRM\_REQ-101

**\_\_device\_\_ \_\_half2 \_\_hsub2 (const \_\_half2 a, const \_\_half2 b)**

Performs `half2` vector subtraction in round-to-nearest-even mode.

**Parameters**

- a**  
- `half2`. Is only being read.
- b**  
- `half2`. Is only being read.

**Returns**

half2

- The

subtraction of vector `b` from `a`.

### Description

Subtracts `half2` input vector `b` from input vector `a` in round-to-nearest-even mode.  
DEEPLearn-SRM\_REQ-104

`__device__ __half2 __hsub2_sat (const __half2 a, const __half2 b)`

Performs `half2` vector subtraction in round-to-nearest-even mode, with saturation to `[0.0, 1.0]`.

### Parameters

**a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

### Returns

`half2`

► The

subtraction of vector `b` from `a`, with respect to saturation.

### Description

Subtracts `half2` input vector `b` from input vector `a` in round-to-nearest-even mode, and clamps the results to range `[0.0, 1.0]`. NaN results are flushed to `+0.0`. TBR

## 1.1.3. Half Comparison Functions

Half Precision Intrinsics

To use these functions include the header file `cuda_fp16.h` in your program.

`__device__ bool __heq (const __half a, const __half b)`

Performs `half` if-equal comparison.

### Parameters

**a**

- `half`. Is only being read.

**b**

- `half`. Is only being read.

**Returns**

bool

- The  
boolean result of if-equal comparison of a and b.

**Description**

Performs `half` if-equal comparison of inputs a and b. NaN inputs generate false results.  
TBR

`__device__ bool __hequ (const __half a, const __half b)`

Performs `half` unordered if-equal comparison.

**Parameters**

- a**  
- half. Is only being read.
- b**  
- half. Is only being read.

**Returns**

bool

- The  
boolean result of unordered if-equal comparison of a and b.

**Description**

Performs `half` if-equal comparison of inputs a and b. NaN inputs generate true results.  
TBR

`__device__ bool __hge (const __half a, const __half b)`

Performs `half` greater-equal comparison.

**Parameters**

- a**  
- half. Is only being read.
- b**  
- half. Is only being read.

**Returns**

bool

- The  
boolean result of greater-equal comparison of a and b.

### Description

Performs `half` greater-equal comparison of inputs a and b. NaN inputs generate false results. TBR

`__device__ bool __hgeu (const __half a, const __half b)`

Performs `half` unordered greater-equal comparison.

### Parameters

- a**  
- half. Is only being read.
- b**  
- half. Is only being read.

### Returns

bool

- The  
boolean result of unordered greater-equal comparison of a and b.

### Description

Performs `half` greater-equal comparison of inputs a and b. NaN inputs generate true results. TBR

`__device__ bool __hgt (const __half a, const __half b)`

Performs `half` greater-than comparison.

### Parameters

- a**  
- half. Is only being read.
- b**  
- half. Is only being read.

### Returns

bool

- The  
boolean result of greater-than comparison of a and b.

**Description**

Performs `half` greater-than comparison of inputs `a` and `b`. NaN inputs generate false results. TBR

`__device__ bool __hgtu (const __half a, const __half b)`

Performs `half` unordered greater-than comparison.

**Parameters**

**a**

- `half`. Is only being read.

**b**

- `half`. Is only being read.

**Returns**

`bool`

- The  
boolean result of unordered greater-than comparison of `a` and `b`.

**Description**

Performs `half` greater-than comparison of inputs `a` and `b`. NaN inputs generate true results. TBR

`__device__ int __hisinf (const __half a)`

Checks if the input `half` number is infinite.

**Parameters**

**a**

- `half`. Is only being read.

**Returns**

`int`

- -1  
iff `a` is equal to negative infinity,
- 1  
iff `a` is equal to positive infinity,
- 0  
otherwise.

**Description**

Checks if the input `half` number `a` is infinite. TBR

`__device__ bool __hisnan (const __half a)`

Determine whether `half` argument is a NaN.

**Parameters**

**a**

- `half`. Is only being read.

**Returns**

`bool`

► `true`

iff argument is NaN.

**Description**

Determine whether `half` value `a` is a NaN. TBR

`__device__ bool __hle (const __half a, const __half b)`

Performs `half` less-equal comparison.

**Parameters**

**a**

- `half`. Is only being read.

**b**

- `half`. Is only being read.

**Returns**

`bool`

► `The`

boolean result of less-equal comparison of `a` and `b`.

**Description**

Performs `half` less-equal comparison of inputs `a` and `b`. NaN inputs generate false results. TBR



**\_\_device\_\_ bool \_\_hleu (const \_\_half a, const \_\_half b)**

Performs `half` unordered less-equal comparison.

### Parameters

**a**

- half. Is only being read.

**b**

- half. Is only being read.

### Returns

bool

► The

boolean result of unordered less-equal comparison of a and b.

### Description

Performs `half` less-equal comparison of inputs a and b. NaN inputs generate true results. TBR

**\_\_device\_\_ bool \_\_hlt (const \_\_half a, const \_\_half b)**

Performs `half` less-than comparison.

### Parameters

**a**

- half. Is only being read.

**b**

- half. Is only being read.

### Returns

bool

► The

boolean result of less-than comparison of a and b.

### Description

Performs `half` less-than comparison of inputs a and b. NaN inputs generate false results. TBR

**\_\_device\_\_ bool \_\_hltu (const \_\_half a, const \_\_half b)**

Performs `half` unordered less-than comparison.

### Parameters

**a**

- half. Is only being read.

**b**

- half. Is only being read.

### Returns

bool

► The

boolean result of unordered less-than comparison of a and b.

### Description

Performs `half` less-than comparison of inputs a and b. NaN inputs generate true results. TBR

**\_\_device\_\_ bool \_\_hne (const \_\_half a, const \_\_half b)**

Performs `half` not-equal comparison.

### Parameters

**a**

- half. Is only being read.

**b**

- half. Is only being read.

### Returns

bool

► The

boolean result of not-equal comparison of a and b.

### Description

Performs `half` not-equal comparison of inputs a and b. NaN inputs generate false results. TBR

**\_\_device\_\_ bool \_\_hneu (const \_\_half a, const \_\_half b)**

Performs `half` unordered not-equal comparison.

### Parameters

**a**

- `half`. Is only being read.

**b**

- `half`. Is only being read.

### Returns

`bool`

► The

boolean result of unordered not-equal comparison of `a` and `b`.

### Description

Performs `half` not-equal comparison of inputs `a` and `b`. NaN inputs generate true results. TBR

## 1.1.4. Half2 Comparison Functions

Half Precision Intrinsics

To use these functions include the header file `cuda_fp16.h` in your program.

**\_\_device\_\_ bool \_\_hbeq2 (const \_\_half2 a, const \_\_half2 b)**

Performs `half2` vector if-equal comparison, and returns boolean true iff both `half` results are true, boolean false otherwise.

### Parameters

**a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

### Returns

`bool`

► `trueif`

both `half` results of if-equal comparison of vectors `a` and `b` are true;

► `falseotherwise`.

**Description**

Performs `half2` vector if-equal comparison of inputs `a` and `b`. The `bool` result is set to `true` only if both `half` if-equal comparisons evaluate to `true`, or `false` otherwise. NaN inputs generate `false` results. TBR

**\_\_device\_\_ bool \_\_hbequ2 (const \_\_half2 a, const \_\_half2 b)**

Performs `half2` vector unordered if-equal comparison, and returns boolean `true` iff both `half` results are `true`, boolean `false` otherwise.

**Parameters**

- a**  
- `half2`. Is only being read.
- b**  
- `half2`. Is only being read.

**Returns**

`bool`

- ▶ `trueif`  
both `half` results of unordered if-equal comparison of vectors `a` and `b` are `true`;
- ▶ `falseotherwise`.

**Description**

Performs `half2` vector if-equal comparison of inputs `a` and `b`. The `bool` result is set to `true` only if both `half` if-equal comparisons evaluate to `true`, or `false` otherwise. NaN inputs generate `true` results. TBR

**\_\_device\_\_ bool \_\_hbge2 (const \_\_half2 a, const \_\_half2 b)**

Performs `half2` vector greater-equal comparison, and returns boolean `true` iff both `half` results are `true`, boolean `false` otherwise.

**Parameters**

- a**  
- `half2`. Is only being read.
- b**  
- `half2`. Is only being read.

**Returns**

`bool`

- ▶ `trueif`

- both `half` results of greater-equal comparison of vectors `a` and `b` are true;
- ▶ false otherwise.

### Description

Performs `half2` vector greater-equal comparison of inputs `a` and `b`. The `bool` result is set to true only if both `half` greater-equal comparisons evaluate to true, or false otherwise. NaN inputs generate false results. TBR

**`__device__ bool __hbgeu2 (const __half2 a, const __half2 b)`**

Performs `half2` vector unordered greater-equal comparison, and returns boolean true iff both `half` results are true, boolean false otherwise.

### Parameters

- a**
  - `half2`. Is only being read.
- b**
  - `half2`. Is only being read.

### Returns

`bool`

- ▶ true if
  - both `half` results of unordered greater-equal comparison of vectors `a` and `b` are true;
- ▶ false otherwise.

### Description

Performs `half2` vector greater-equal comparison of inputs `a` and `b`. The `bool` result is set to true only if both `half` greater-equal comparisons evaluate to true, or false otherwise. NaN inputs generate true results. TBR

**`__device__ bool __hbg2 (const __half2 a, const __half2 b)`**

Performs `half2` vector greater-than comparison, and returns boolean true iff both `half` results are true, boolean false otherwise.

### Parameters

- a**
  - `half2`. Is only being read.
- b**
  - `half2`. Is only being read.

**Returns**

bool

- ▶ trueif  
both `half` results of greater-than comparison of vectors `a` and `b` are true;
- ▶ falseotherwise.

**Description**

Performs `half2` vector greater-than comparison of inputs `a` and `b`. The bool result is set to true only if both `half` greater-than comparisons evaluate to true, or false otherwise. NaN inputs generate false results. TBR

`__device__ bool __hbgtu2 (const __half2 a, const __half2 b)`

Performs `half2` vector unordered greater-than comparison, and returns boolean true iff both `half` results are true, boolean false otherwise.

**Parameters**

- a**  
- `half2`. Is only being read.
- b**  
- `half2`. Is only being read.

**Returns**

bool

- ▶ trueif  
both `half` results of unordered greater-than comparison of vectors `a` and `b` are true;
- ▶ falseotherwise.

**Description**

Performs `half2` vector greater-than comparison of inputs `a` and `b`. The bool result is set to true only if both `half` greater-than comparisons evaluate to true, or false otherwise. NaN inputs generate true results. TBR

**\_\_device\_\_ bool \_\_hble2 (const \_\_half2 a, const \_\_half2 b)**

Performs `half2` vector less-equal comparison, and returns boolean true iff both `half` results are true, boolean false otherwise.

**Parameters****a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

**Returns**

bool

► trueif

both `half` results of less-equal comparison of vectors `a` and `b` are true;

► falseotherwise.

**Description**

Performs `half2` vector less-equal comparison of inputs `a` and `b`. The bool result is set to true only if both `half` less-equal comparisons evaluate to true, or false otherwise. NaN inputs generate false results. TBR

**\_\_device\_\_ bool \_\_hbleu2 (const \_\_half2 a, const \_\_half2 b)**

Performs `half2` vector unordered less-equal comparison, and returns boolean true iff both `half` results are true, boolean false otherwise.

**Parameters****a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

**Returns**

bool

► trueif

both `half` results of unordered less-equal comparison of vectors `a` and `b` are true;

► falseotherwise.

## Description

Performs `half2` vector less-equal comparison of inputs `a` and `b`. The `bool` result is set to `true` only if both `half` less-equal comparisons evaluate to `true`, or `false` otherwise. NaN inputs generate `true` results. TBR

**`__device__ bool __hblt2 (const __half2 a, const __half2 b)`**

Performs `half2` vector less-than comparison, and returns boolean `true` iff both `half` results are `true`, boolean `false` otherwise.

## Parameters

**a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

## Returns

`bool`

► `trueif`

both `half` results of less-than comparison of vectors `a` and `b` are `true`;

► `falseotherwise`.

## Description

Performs `half2` vector less-than comparison of inputs `a` and `b`. The `bool` result is set to `true` only if both `half` less-than comparisons evaluate to `true`, or `false` otherwise. NaN inputs generate `false` results. TBR

**`__device__ bool __hbltu2 (const __half2 a, const __half2 b)`**

Performs `half2` vector unordered less-than comparison, and returns boolean `true` iff both `half` results are `true`, boolean `false` otherwise.

## Parameters

**a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

## Returns

`bool`

► `trueif`



- both `half` results of unordered less-than comparison of vectors `a` and `b` are true;
- ▶ false otherwise.

### Description

Performs `half2` vector less-than comparison of inputs `a` and `b`. The `bool` result is set to true only if both `half` less-than comparisons evaluate to true, or false otherwise. NaN inputs generate true results. TBR

**`__device__ bool __hbfne2 (const __half2 a, const __half2 b)`**

Performs `half2` vector not-equal comparison, and returns boolean true iff both `half` results are true, boolean false otherwise.

### Parameters

- a**
  - `half2`. Is only being read.
- b**
  - `half2`. Is only being read.

### Returns

`bool`

- ▶ `trueif`
  - both `half` results of not-equal comparison of vectors `a` and `b` are true,
- ▶ `false`
  - otherwise.

### Description

Performs `half2` vector not-equal comparison of inputs `a` and `b`. The `bool` result is set to true only if both `half` not-equal comparisons evaluate to true, or false otherwise. NaN inputs generate false results. TBR

**`__device__ bool __hbneu2 (const __half2 a, const __half2 b)`**

Performs `half2` vector unordered not-equal comparison, and returns boolean true iff both `half` results are true, boolean false otherwise.

### Parameters

- a**
  - `half2`. Is only being read.
- b**
  - `half2`. Is only being read.

**Returns**

bool

- ▶ trueif  
both `half` results of unordered not-equal comparison of vectors `a` and `b` are true;
- ▶ falseotherwise.

**Description**

Performs `half2` vector not-equal comparison of inputs `a` and `b`. The bool result is set to true only if both `half` not-equal comparisons evaluate to true, or false otherwise. NaN inputs generate true results. TBR

`__device__ __half2 __heq2 (const __half2 a, const __half2 b)`

Performs `half2` vector if-equal comparison.

**Parameters**

- a**  
- `half2`. Is only being read.
- b**  
- `half2`. Is only being read.

**Returns**

`half2`

- ▶ The  
vector result of if-equal comparison of vectors `a` and `b`.

**Description**

Performs `half2` vector if-equal comparison of inputs `a` and `b`. The corresponding `half` results are set to 1.0 for true, or 0.0 for false. NaN inputs generate false results. TBR

`__device__ __half2 __hequ2 (const __half2 a, const __half2 b)`

Performs `half2` vector unordered if-equal comparison.

**Parameters**

- a**  
- `half2`. Is only being read.
- b**  
- `half2`. Is only being read.

**Returns**

half2

- The  
vector result of unordered if-equal comparison of vectors a and b.

**Description**

Performs half2 vector if-equal comparison of inputs a and b. The corresponding half results are set to 1.0 for true, or 0.0 for false. NaN inputs generate true results. TBR

**\_\_device\_\_ \_\_half2 \_\_hge2 (const \_\_half2 a, const \_\_half2 b)**

Performs half2 vector greater-equal comparison.

**Parameters**

- a**  
- half2. Is only being read.
- b**  
- half2. Is only being read.

**Returns**

half2

- The  
vector result of greater-equal comparison of vectors a and b.

**Description**

Performs half2 vector greater-equal comparison of inputs a and b. The corresponding half results are set to 1.0 for true, or 0.0 for false. NaN inputs generate false results. TBR

**\_\_device\_\_ \_\_half2 \_\_hgeu2 (const \_\_half2 a, const \_\_half2 b)**

Performs half2 vector unordered greater-equal comparison.

**Parameters**

- a**  
- half2. Is only being read.
- b**  
- half2. Is only being read.

**Returns**

half2

- The `half2` vector result of unordered greater-equal comparison of vectors `a` and `b`.

### Description

Performs `half2` vector greater-equal comparison of inputs `a` and `b`. The corresponding `half` results are set to 1.0 for true, or 0.0 for false. NaN inputs generate true results. TBR

**`__device__ __half2 __hgt2 (const __half2 a, const __half2 b)`**

Performs `half2` vector greater-than comparison.

### Parameters

- a**  
- `half2`. Is only being read.
- b**  
- `half2`. Is only being read.

### Returns

`half2`

- The `half2` vector result of greater-than comparison of vectors `a` and `b`.

### Description

Performs `half2` vector greater-than comparison of inputs `a` and `b`. The corresponding `half` results are set to 1.0 for true, or 0.0 for false. NaN inputs generate false results. TBR

**`__device__ __half2 __hgtu2 (const __half2 a, const __half2 b)`**

Performs `half2` vector unordered greater-than comparison.

### Parameters

- a**  
- `half2`. Is only being read.
- b**  
- `half2`. Is only being read.

### Returns

`half2`

- The `half2` vector result of unordered greater-than comparison of vectors `a` and `b`.

**Description**

Performs `half2` vector greater-than comparison of inputs `a` and `b`. The corresponding `half` results are set to 1.0 for true, or 0.0 for false. NaN inputs generate true results. TBR

`__device__ __half2 __hisnan2 (const __half2 a)`

Determine whether `half2` argument is a NaN.

**Parameters**

**a**

- `half2`. Is only being read.

**Returns**

`half2`

► The

`half2` with the corresponding `half` results set to 1.0 for NaN, 0.0 otherwise.

**Description**

Determine whether each half of input `half2` number `a` is a NaN. TBR

`__device__ __half2 __hle2 (const __half2 a, const __half2 b)`

Performs `half2` vector less-equal comparison.

**Parameters**

**a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

**Returns**

`half2`

► The

`half2` result of less-equal comparison of vectors `a` and `b`.

**Description**

Performs `half2` vector less-equal comparison of inputs `a` and `b`. The corresponding `half` results are set to 1.0 for true, or 0.0 for false. NaN inputs generate false results. TBR

**\_\_device\_\_ \_\_half2 \_\_hleu2 (const \_\_half2 a, const \_\_half2 b)**

Performs `half2` vector unordered less-equal comparison.

### Parameters

**a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

### Returns

`half2`

► The

vector result of unordered less-equal comparison of vectors `a` and `b`.

### Description

Performs `half2` vector less-equal comparison of inputs `a` and `b`. The corresponding `half` results are set to 1.0 for true, or 0.0 for false. NaN inputs generate true results. TBR

**\_\_device\_\_ \_\_half2 \_\_hlt2 (const \_\_half2 a, const \_\_half2 b)**

Performs `half2` vector less-than comparison.

### Parameters

**a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

### Returns

`half2`

► The

`half2` vector result of less-than comparison of vectors `a` and `b`.

### Description

Performs `half2` vector less-than comparison of inputs `a` and `b`. The corresponding `half` results are set to 1.0 for true, or 0.0 for false. NaN inputs generate false results. TBR

**\_\_device\_\_ \_\_half2 \_\_hltu2 (const \_\_half2 a, const \_\_half2 b)**

Performs `half2` vector unordered less-than comparison.

### Parameters

**a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

### Returns

`half2`

► The

vector result of unordered less-than comparison of vectors `a` and `b`.

### Description

Performs `half2` vector less-than comparison of inputs `a` and `b`. The corresponding `half` results are set to 1.0 for true, or 0.0 for false. NaN inputs generate true results. TBR

**\_\_device\_\_ \_\_half2 \_\_hne2 (const \_\_half2 a, const \_\_half2 b)**

Performs `half2` vector not-equal comparison.

### Parameters

**a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

### Returns

`half2`

► The

vector result of not-equal comparison of vectors `a` and `b`.

### Description

Performs `half2` vector not-equal comparison of inputs `a` and `b`. The corresponding `half` results are set to 1.0 for true, or 0.0 for false. NaN inputs generate false results. TBR

**\_\_device\_\_ \_\_half2 \_\_hneu2 (const \_\_half2 a, const \_\_half2 b)**

Performs `half2` vector unordered not-equal comparison.

### Parameters

**a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

### Returns

`half2`

► The

vector result of unordered not-equal comparison of vectors `a` and `b`.

### Description

Performs `half2` vector not-equal comparison of inputs `a` and `b`. The corresponding `half` results are set to 1.0 for true, or 0.0 for false. NaN inputs generate true results. TBR

## 1.1.5. Half Precision Conversion And Data Movement

### Half Precision Intrinsics

To use these functions include the header file `cuda_fp16.h` in your program.

**\_\_host\_\_ \_\_device\_\_ \_\_half2 \_\_float2half2\_rn (const float2 a)**

Converts both components of `float2` number to half precision in round-to-nearest-even mode and returns `half2` with converted values.

### Parameters

**a**

- `float2`. Is only being read.

### Returns

`half2`

► The

`half2` which has corresponding halves equal to the converted `float2` components.



**Description**

Converts both components of `float2` to half precision in round-to-nearest mode and combines the results into one `half2` number. Low 16 bits of the return value correspond to `a.x` and high 16 bits of the return value correspond to `a.y`. TBR

**`__host__ __device__ __half __float2half (const float a)`**

Converts float number to half precision in round-to-nearest-even mode and returns `half` with converted value.

**Parameters**

**a**

- float. Is only being read.

**Returns**

`half`

► `\p`

a converted to half.

**Description**

Converts float number a to half precision in round-to-nearest-even mode. TBR

**`__host__ __device__ __half2 __float2half2_rn (const float a)`**

Converts input to half precision in round-to-nearest-even mode and populates both halves of `half2` with converted value.

**Parameters**

**a**

- float. Is only being read.

**Returns**

`half2`

► The

`half2` value with both halves equal to the converted half precision number.

**Description**

Converts input a to half precision in round-to-nearest-even mode and populates both halves of `half2` with converted value. TBR

**\_\_host\_\_ \_\_device\_\_ \_\_half \_\_float2half\_rd (const float a)**

Converts float number to half precision in round-down mode and returns `half` with converted value.

**Parameters****a**

- float. Is only being read.

**Returns**

`half`

► `\p`

a converted to half.

**Description**

Converts float number a to half precision in round-down mode. TBR

**\_\_host\_\_ \_\_device\_\_ \_\_half \_\_float2half\_rn (const float a)**

Converts float number to half precision in round-to-nearest-even mode and returns `half` with converted value.

**Parameters****a**

- float. Is only being read.

**Returns**

`half`

► `\p`

a converted to half.

**Description**

Converts float number a to half precision in round-to-nearest-even mode. TBR

**\_\_host\_\_ \_\_device\_\_ \_\_half \_\_float2half\_ru (const float a)**

Converts float number to half precision in round-up mode and returns `half` with converted value.

**Parameters****a**

- float. Is only being read.

**Returns**

`half`

► `\p`

a converted to half.

**Description**

Converts float number a to half precision in round-up mode. TBR

**\_\_host\_\_ \_\_device\_\_ \_\_half \_\_float2half\_rz (const float a)**

Converts float number to half precision in round-towards-zero mode and returns `half` with converted value.

**Parameters****a**

- float. Is only being read.

**Returns**

`half`

► `\p`

a converted to half.

**Description**

Converts float number a to half precision in round-towards-zero mode. TBR

## `__host__ __device__ __half2 __floats2half2_rn (const float a, const float b)`

Converts both input floats to half precision in round-to-nearest-even mode and returns `half2` with converted values.

### Parameters

- a**  
- float. Is only being read.
- b**  
- float. Is only being read.

### Returns

`half2`

- The  
`half2` value with corresponding halves equal to the converted input floats.

### Description

Converts both input floats to half precision in round-to-nearest-even mode and combines the results into one `half2` number. Low 16 bits of the return value correspond to the input `a`, high 16 bits correspond to the input `b`. TBR

## `__host__ __device__ float2 __half22float2 (const __half2 a)`

Converts both halves of `half2` to `float2` and returns the result.

### Parameters

- a**  
- `half2`. Is only being read.

### Returns

`float2`

- `\p`  
a converted to `float2`.

### Description

Converts both halves of `half2` input `a` to `float2` and returns the result. TBR

**\_\_host\_\_ \_\_device\_\_ float \_\_half2float (const \_\_half a)**

Converts `half` number to float.

### Parameters

**a**

- float. Is only being read.

### Returns

float

► \p

a converted to float.

### Description

Converts half number a to float. TBR

**\_\_device\_\_ \_\_half2 \_\_half2half2 (const \_\_half a)**

Returns `half2` with both halves equal to the input value.

### Parameters

**a**

- half. Is only being read.

### Returns

half2

► The

vector which has both its halves equal to the input a.

### Description

Returns `half2` number with both halves equal to the input a `half` number. TBR

**\_\_device\_\_ int \_\_half2int\_rd (\_\_half h)**

Convert a half to a signed integer in round-down mode.

### Parameters

**h**

- half. Is only being read.

**Returns**

int

► \p

h converted to a signed integer.

**Description**

Convert the half-precision floating point value `h` to a signed integer in round-down mode. TBR

`__device__ int __half2int_rn (__half h)`

Convert a half to a signed integer in round-to-nearest-even mode.

**Parameters**

**h**

- half. Is only being read.

**Returns**

int

► \p

h converted to a signed integer.

**Description**

Convert the half-precision floating point value `h` to a signed integer in round-to-nearest-even mode. TBR

`__device__ int __half2int_ru (__half h)`

Convert a half to a signed integer in round-up mode.

**Parameters**

**h**

- half. Is only being read.

**Returns**

int

► \p

h converted to a signed integer.

**Description**

Convert the half-precision floating point value `h` to a signed integer in round-up mode. TBR

`__device__ int __half2int_rz (__half h)`

Convert a half to a signed integer in round-towards-zero mode.

**Parameters**

**h**

- half. Is only being read.

**Returns**

int

► \p

h converted to a signed integer.

**Description**

Convert the half-precision floating point value `h` to a signed integer in round-towards-zero mode. TBR

`__device__ long long int __half2ll_rd (__half h)`

Convert a half to a signed 64-bit integer in round-down mode.

**Parameters**

**h**

- half. Is only being read.

**Returns**

long long int

► \p

h converted to a signed 64-bit integer.

**Description**

Convert the half-precision floating point value `h` to a signed 64-bit integer in round-down mode. TBR

**\_\_device\_\_ long long int \_\_half2ll\_rn (\_\_half h)**

Convert a half to a signed 64-bit integer in round-to-nearest-even mode.

### Parameters

**h**

- half. Is only being read.

### Returns

long long int

► \p

h converted to a signed 64-bit integer.

### Description

Convert the half-precision floating point value h to a signed 64-bit integer in round-to-nearest-even mode. TBR

**\_\_device\_\_ long long int \_\_half2ll\_ru (\_\_half h)**

Convert a half to a signed 64-bit integer in round-up mode.

### Parameters

**h**

- half. Is only being read.

### Returns

long long int

► \p

h converted to a signed 64-bit integer.

### Description

Convert the half-precision floating point value h to a signed 64-bit integer in round-up mode. TBR



**\_\_device\_\_ long long int \_\_half2ll\_rz (\_\_half h)**

Convert a half to a signed 64-bit integer in round-towards-zero mode.

### Parameters

**h**

- half. Is only being read.

### Returns

long long int

► \p

h converted to a signed 64-bit integer.

### Description

Convert the half-precision floating point value *h* to a signed 64-bit integer in round-towards-zero mode. TBR

**\_\_device\_\_ short int \_\_half2short\_rd (\_\_half h)**

Convert a half to a signed short integer in round-down mode.

### Parameters

**h**

- half. Is only being read.

### Returns

short int

► \p

h converted to a signed short integer.

### Description

Convert the half-precision floating point value *h* to a signed short integer in round-down mode. TBR

**\_\_device\_\_ short int \_\_half2short\_rn (\_\_half h)**

Convert a half to a signed short integer in round-to-nearest-even mode.

### Parameters

**h**

- half. Is only being read.

### Returns

short int

► \p

h converted to a signed short integer.

### Description

Convert the half-precision floating point value *h* to a signed short integer in round-to-nearest-even mode. TBR

**\_\_device\_\_ short int \_\_half2short\_ru (\_\_half h)**

Convert a half to a signed short integer in round-up mode.

### Parameters

**h**

- half. Is only being read.

### Returns

short int

► \p

h converted to a signed short integer.

### Description

Convert the half-precision floating point value *h* to a signed short integer in round-up mode. TBR

**\_\_device\_\_ short int \_\_half2short\_rz (\_\_half h)**

Convert a half to a signed short integer in round-towards-zero mode.

### Parameters

**h**

- half. Is only being read.

### Returns

short int

► \p

h converted to a signed short integer.

### Description

Convert the half-precision floating point value *h* to a signed short integer in round-towards-zero mode. TBR

**\_\_device\_\_ unsigned int \_\_half2uint\_rd (\_\_half h)**

Convert a half to an unsigned integer in round-down mode.

### Parameters

**h**

- half. Is only being read.

### Returns

unsigned int

► \p

h converted to an unsigned integer.

### Description

Convert the half-precision floating point value *h* to an unsigned integer in round-down mode. TBR

## `__device__ unsigned int __half2uint_rn (__half h)`

Convert a half to an unsigned integer in round-to-nearest-even mode.

### Parameters

**h**

- half. Is only being read.

### Returns

unsigned int

► \p

h converted to an unsigned integer.

### Description

Convert the half-precision floating point value *h* to an unsigned integer in round-to-nearest-even mode. TBR

## `__device__ unsigned int __half2uint_ru (__half h)`

Convert a half to an unsigned integer in round-up mode.

### Parameters

**h**

- half. Is only being read.

### Returns

unsigned int

► \p

h converted to an unsigned integer.

### Description

Convert the half-precision floating point value *h* to an unsigned integer in round-up mode. TBR

**\_\_device\_\_ unsigned int \_\_half2uint\_rz (\_\_half h)**

Convert a half to an unsigned integer in round-towards-zero mode.

### Parameters

**h**

- half. Is only being read.

### Returns

unsigned int

► \p

h converted to an unsigned integer.

### Description

Convert the half-precision floating point value *h* to an unsigned integer in round-towards-zero mode. TBR

**\_\_device\_\_ unsigned long long int \_\_half2ull\_rd (\_\_half h)**

Convert a half to an unsigned 64-bit integer in round-down mode.

### Parameters

**h**

- half. Is only being read.

### Returns

unsigned long long int

► \p

h converted to an unsigned 64-bit integer.

### Description

Convert the half-precision floating point value *h* to an unsigned 64-bit integer in round-down mode. TBR

**\_\_device\_\_ unsigned long long int \_\_half2ull\_rn (\_\_half h)**

Convert a half to an unsigned 64-bit integer in round-to-nearest-even mode.

### Parameters

**h**

- half. Is only being read.

### Returns

unsigned long long int

► \p

h converted to an unsigned 64-bit integer.

### Description

Convert the half-precision floating point value h to an unsigned 64-bit integer in round-to-nearest-even mode. TBR

**\_\_device\_\_ unsigned long long int \_\_half2ull\_ru (\_\_half h)**

Convert a half to an unsigned 64-bit integer in round-up mode.

### Parameters

**h**

- half. Is only being read.

### Returns

unsigned long long int

► \p

h converted to an unsigned 64-bit integer.

### Description

Convert the half-precision floating point value h to an unsigned 64-bit integer in round-up mode. TBR

**\_\_device\_\_ unsigned long long int \_\_half2ull\_rz (\_\_half h)**

Convert a half to an unsigned 64-bit integer in round-towards-zero mode.

### Parameters

**h**

- half. Is only being read.

### Returns

unsigned long long int

► \p

h converted to an unsigned 64-bit integer.

### Description

Convert the half-precision floating point value h to an unsigned 64-bit integer in round-towards-zero mode. TBR

**\_\_device\_\_ unsigned short int \_\_half2ushort\_rd (\_\_half h)**

Convert a half to an unsigned short integer in round-down mode.

### Parameters

**h**

- half. Is only being read.

### Returns

unsigned short int

► \p

h converted to an unsigned short integer.

### Description

Convert the half-precision floating point value h to an unsigned short integer in round-down mode. TBR

**\_\_device\_\_ unsigned short int \_\_half2ushort\_rn (\_\_half h)**

Convert a half to an unsigned short integer in round-to-nearest-even mode.

### Parameters

**h**

- half. Is only being read.

### Returns

unsigned short int

► \p

h converted to an unsigned short integer.

### Description

Convert the half-precision floating point value *h* to an unsigned short integer in round-to-nearest-even mode. TBR

**\_\_device\_\_ unsigned short int \_\_half2ushort\_ru (\_\_half h)**

Convert a half to an unsigned short integer in round-up mode.

### Parameters

**h**

- half. Is only being read.

### Returns

unsigned short int

► \p

h converted to an an unsigned short integer.

### Description

Convert the half-precision floating point value *h* to an unsigned short integer in round-up mode. TBR



**\_\_device\_\_ unsigned short int \_\_half2ushort\_rz (\_\_half h)**

Convert a half to an unsigned short integer in round-towards-zero mode.

### Parameters

**h**

- half. Is only being read.

### Returns

unsigned short int

► \p

h converted to an unsigned short integer.

### Description

Convert the half-precision floating point value `h` to an unsigned short integer in round-towards-zero mode. TBR

**\_\_device\_\_ short int \_\_half\_as\_short (const \_\_half h)**

Reinterprets bits in a `half` as a signed short integer.

### Parameters

**h**

- half. Is only being read.

### Returns

short int

► The

reinterpreted value.

### Description

Reinterprets the bits in the half-precision floating point number `h` as a signed short integer. TBR

**\_\_device\_\_ unsigned short int \_\_half\_as\_ushort (const \_\_half h)**

Reinterprets bits in a `half` as an unsigned short integer.

### Parameters

**h**

- `half`. Is only being read.

### Returns

unsigned short int

- The  
reinterpreted value.

### Description

Reinterprets the bits in the half-precision floating point `h` as an unsigned short number. TBR

**\_\_device\_\_ \_\_half2 \_\_halves2half2 (const \_\_half a, const \_\_half b)**

Combines two `half` numbers into one `half2` number.

### Parameters

**a**

- `half`. Is only being read.

**b**

- `half`. Is only being read.

### Returns

`half2`

- The  
`half2` with one `half` equal to `a` and the other to `b`.

### Description

Combines two input `half` number `a` and `b` into one `half2` number. Input `a` is stored in low 16 bits of the return value, input `b` is stored in high 16 bits of the return value. TBR

**\_\_host\_\_ \_\_device\_\_ float \_\_high2float (const \_\_half2 a)**

Converts high 16 bits of `half2` to float and returns the result.

### Parameters

**a**

- `half2`. Is only being read.

### Returns

float

- The high 16 bits of `a` converted to float.

### Description

Converts high 16 bits of `half2` input `a` to 32 bit floating point number and returns the result. TBR

**\_\_device\_\_ \_\_half \_\_high2half (const \_\_half2 a)**

Returns high 16 bits of `half2` input.

### Parameters

**a**

- `half2`. Is only being read.

### Returns

half

- The high 16 bits of the input.

### Description

Returns high 16 bits of `half2` input `a`. TBR

**\_\_device\_\_ \_\_half2 \_\_high2half2 (const \_\_half2 a)**

Extracts high 16 bits from `half2` input.

### Parameters

**a**

- `half2`. Is only being read.

**Returns**

half2

- The

half2 with both halves equal to the high 16 bits of the input.

**Description**

Extracts high 16 bits from `half2` input `a` and returns a new `half2` number which has both halves equal to the extracted bits. TBR

**`__device__ __half2 __high2half2 (const __half2 a, const __half2 b)`**

Extracts high 16 bits from each of the two `half2` inputs and combines into one `half2` number.

**Parameters**

**a**

- `half2`. Is only being read.

**b**

- `half2`. Is only being read.

**Returns**

half2

- The

high 16 bits of `a` and of `b`.

**Description**

Extracts high 16 bits from each of the two `half2` inputs and combines into one `half2` number. High 16 bits from input `a` is stored in low 16 bits of the return value, high 16 bits from input `b` is stored in high 16 bits of the return value. TBR

**`__device__ __half __int2half_rd (int i)`**

Convert a signed integer to a half in round-down mode.

**Parameters**

**i**

- `int`. Is only being read.

**Returns**

half

- \p  
i converted to half.

### Description

Convert the signed integer value `i` to a half-precision floating point value in round-down mode. TBR

**\_\_device\_\_ \_\_half \_\_int2half\_rn (int i)**

Convert a signed integer to a half in round-to-nearest-even mode.

### Parameters

- i**  
- int. Is only being read.

### Returns

half

- \p  
i converted to half.

### Description

Convert the signed integer value `i` to a half-precision floating point value in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half \_\_int2half\_ru (int i)**

Convert a signed integer to a half in round-up mode.

### Parameters

- i**  
- int. Is only being read.

### Returns

half

- \p  
i converted to half.

### Description

Convert the signed integer value `i` to a half-precision floating point value in round-up mode. TBR

**\_\_device\_\_ \_\_half \_\_int2half\_rz (int i)**

Convert a signed integer to a half in round-towards-zero mode.

**Parameters**

**i**

- int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the signed integer value *i* to a half-precision floating point value in round-towards-zero mode. TBR

**\_\_device\_\_ \_\_half \_\_ll2half\_rd (long long int i)**

Convert a signed 64-bit integer to a half in round-down mode.

**Parameters**

**i**

- long long int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the signed 64-bit integer value *i* to a half-precision floating point value in round-down mode. TBR

**\_\_device\_\_ \_\_half \_\_ll2half\_rn (long long int i)**

Convert a signed 64-bit integer to a half in round-to-nearest-even mode.

**Parameters**

**i**

- long long int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the signed 64-bit integer value *i* to a half-precision floating point value in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half \_\_ll2half\_ru (long long int i)**

Convert a signed 64-bit integer to a half in round-up mode.

**Parameters**

**i**

- long long int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the signed 64-bit integer value *i* to a half-precision floating point value in round-up mode. TBR

**\_\_device\_\_ \_\_half \_\_ll2half\_rz (long long int i)**

Convert a signed 64-bit integer to a half in round-towards-zero mode.

### Parameters

**i**

- long long int. Is only being read.

### Returns

half

► \p

i converted to half.

### Description

Convert the signed 64-bit integer value `i` to a half-precision floating point value in round-towards-zero mode. TBR

**\_\_host\_\_ \_\_device\_\_ float \_\_low2float (const \_\_half2 a)**

Converts low 16 bits of `half2` to float and returns the result.

### Parameters

**a**

- half2. Is only being read.

### Returns

float

► The

low 16 bits of `a` converted to float.

### Description

Converts low 16 bits of `half2` input `a` to 32 bit floating point number and returns the result. TBR



**\_\_device\_\_ \_\_half \_\_low2half (const \_\_half2 a)**

Returns low 16 bits of `half2` input.

### Parameters

**a**

- `half2`. Is only being read.

### Returns

`half`

► Returns

`half` which contains low 16 bits of the input `a`.

### Description

Returns low 16 bits of `half2` input `a`. TBR

**\_\_device\_\_ \_\_half2 \_\_low2half2 (const \_\_half2 a)**

Extracts low 16 bits from `half2` input.

### Parameters

**a**

- `half2`. Is only being read.

### Returns

`half2`

► The

`half2` with both halves equal to the low 16 bits of the input.

### Description

Extracts low 16 bits from `half2` input `a` and returns a new `half2` number which has both halves equal to the extracted bits. TBR

**\_\_device\_\_ \_\_half2 \_\_lowhigh2highlow (const \_\_half2 a)**

Swaps both halves of the `half2` input.

### Parameters

**a**

- `half2`. Is only being read.

**Returns**

half2

- \p  
a with its halves being swapped.

**Description**

Swaps both halves of the half2 input and returns a new half2 number with swapped halves. TBR

**\_\_device\_\_ \_\_half2 \_\_lows2half2 (const \_\_half2 a, const \_\_half2 b)**

Extracts low 16 bits from each of the two half2 inputs and combines into one half2 number.

**Parameters**

- a**  
- half2. Is only being read.
- b**  
- half2. Is only being read.

**Returns**

half2

- The  
low 16 bits of a and of b.

**Description**

Extracts low 16 bits from each of the two half2 inputs and combines into one half2 number. Low 16 bits from input a is stored in low 16 bits of the return value, low 16 bits from input b is stored in high 16 bits of the return value. TBR

**\_\_device\_\_ \_\_half \_\_shfl\_down\_sync (unsigned mask, \_\_half var, unsigned int delta, int width)**

Exchange a variable between threads within a warp. Copy from a thread with higher ID relative to the caller.

**Parameters**

- mask**  
- unsigned int. Is only being read.
- var**  
- half. Is only being read.

**delta**

- int. Is only being read.

**width**

- int. Is only being read.

**Returns**

Returns the 2-byte word referenced by var from the source thread ID as half. If the source thread ID is out of range or the source thread has exited, the calling thread's own var is returned.

**Description**

Calculates a source thread ID by adding delta to the caller's thread ID. The value of var held by the resulting thread ID is returned: this has the effect of shifting var down the warp by delta threads. If width is less than warpSize then each subsection of the warp behaves as a separate entity with a starting logical thread ID of 0. As for `__shfl_up_sync()`, the ID number of the source thread will not wrap around the value of width and so the upper delta threads will remain unchanged.

**`__device__ __half2 __shfl_down_sync (unsigned mask, __half2 var, unsigned int delta, int width)`**

Exchange a variable between threads within a warp. Copy from a thread with higher ID relative to the caller.

**Parameters****mask**

- unsigned int. Is only being read.

**var**

- half2. Is only being read.

**delta**

- int. Is only being read.

**width**

- int. Is only being read.

**Returns**

Returns the 4-byte word referenced by var from the source thread ID as half2. If the source thread ID is out of range or the source thread has exited, the calling thread's own var is returned.

**Description**

Calculates a source thread ID by adding delta to the caller's thread ID. The value of var held by the resulting thread ID is returned: this has the effect of shifting var

down the warp by delta threads. If width is less than warpSize then each subsection of the warp behaves as a separate entity with a starting logical thread ID of 0. As for `__shfl_up_sync()`, the ID number of the source thread will not wrap around the value of width and so the upper delta threads will remain unchanged.

**`__device__ __half __shfl_sync (unsigned mask, __half var, int delta, int width)`**

Exchange a variable between threads within a warp. Direct copy from indexed thread.

### Parameters

#### **mask**

- unsigned int. Is only being read.

#### **var**

- half. Is only being read.

#### **delta**

- int. Is only being read.

#### **width**

- int. Is only being read.

### Returns

Returns the 2-byte word referenced by var from the source thread ID as half. If the source thread ID is out of range or the source thread has exited, the calling thread's own var is returned.

### Description

Returns the value of var held by the thread whose ID is given by delta. If width is less than warpSize then each subsection of the warp behaves as a separate entity with a starting logical thread ID of 0. If delta is outside the range [0:width-1], the value returned corresponds to the value of var held by the delta modulo width (i.e. within the same subsection). width must have a value which is a power of 2; results are undefined if width is not a power of 2, or is a number greater than warpSize.

**`__device__ __half2 __shfl_sync (unsigned mask, __half2 var, int delta, int width)`**

Exchange a variable between threads within a warp. Direct copy from indexed thread.

### Parameters

#### **mask**

- unsigned int. Is only being read.

#### **var**

- half2. Is only being read.

**delta**

- int. Is only being read.

**width**

- int. Is only being read.

**Returns**

Returns the 4-byte word referenced by var from the source thread ID as half2. If the source thread ID is out of range or the source thread has exited, the calling thread's own var is returned.

**Description**

Returns the value of var held by the thread whose ID is given by delta. If width is less than warpSize then each subsection of the warp behaves as a separate entity with a starting logical thread ID of 0. If delta is outside the range [0:width-1], the value returned corresponds to the value of var held by the delta modulo width (i.e. within the same subsection). width must have a value which is a power of 2; results are undefined if width is not a power of 2, or is a number greater than warpSize. TBR

## **\_\_device\_\_ \_\_half \_\_shfl\_up\_sync (unsigned mask, \_\_half var, unsigned int delta, int width)**

Exchange a variable between threads within a warp. Copy from a thread with lower ID relative to the caller.

**Parameters****mask**

- unsigned int. Is only being read.

**var**

- half. Is only being read.

**delta**

- int. Is only being read.

**width**

- int. Is only being read.

**Returns**

Returns the 2-byte word referenced by var from the source thread ID as half. If the source thread ID is out of range or the source thread has exited, the calling thread's own var is returned.

**Description**

Calculates a source thread ID by subtracting delta from the caller's lane ID. The value of var held by the resulting lane ID is returned: in effect, var is shifted up the warp by

delta threads. If width is less than warpSize then each subsection of the warp behaves as a separate entity with a starting logical thread ID of 0. The source thread index will not wrap around the value of width, so effectively the lower delta threads will be unchanged. width must have a value which is a power of 2; results are undefined if width is not a power of 2, or is a number greater than warpSize.

**\_\_device\_\_ \_\_half2 \_\_shfl\_up\_sync (unsigned mask, \_\_half2 var, unsigned int delta, int width)**

Exchange a variable between threads within a warp. Copy from a thread with lower ID relative to the caller.

### Parameters

#### **mask**

- unsigned int. Is only being read.

#### **var**

- half2. Is only being read.

#### **delta**

- int. Is only being read.

#### **width**

- int. Is only being read.

### Returns

Returns the 4-byte word referenced by var from the source thread ID as half2. If the source thread ID is out of range or the source thread has exited, the calling thread's own var is returned.

### Description

Calculates a source thread ID by subtracting delta from the caller's lane ID. The value of var held by the resulting lane ID is returned: in effect, var is shifted up the warp by delta threads. If width is less than warpSize then each subsection of the warp behaves as a separate entity with a starting logical thread ID of 0. The source thread index will not wrap around the value of width, so effectively the lower delta threads will be unchanged. width must have a value which is a power of 2; results are undefined if width is not a power of 2, or is a number greater than warpSize.

## `__device__ __half __shfl_xor_sync (unsigned mask, __half var, int delta, int width)`

Exchange a variable between threads within a warp. Copy from a thread based on bitwise XOR of own thread ID.

### Parameters

#### **mask**

- unsigned int. Is only being read.

#### **var**

- half. Is only being read.

#### **delta**

- int. Is only being read.

#### **width**

- int. Is only being read.

### Returns

Returns the 2-byte word referenced by var from the source thread ID as half. If the source thread ID is out of range or the source thread has exited, the calling thread's own var is returned.

### Description

Calculates a source thread ID by performing a bitwise XOR of the caller's thread ID with mask: the value of var held by the resulting thread ID is returned. If width is less than warpSize then each group of width consecutive threads are able to access elements from earlier groups of threads, however if they attempt to access elements from later groups of threads their own value of var will be returned. This mode implements a butterfly addressing pattern such as is used in tree reduction and broadcast.

## `__device__ __half2 __shfl_xor_sync (unsigned mask, __half2 var, int delta, int width)`

Exchange a variable between threads within a warp. Copy from a thread based on bitwise XOR of own thread ID.

### Parameters

#### **mask**

- unsigned int. Is only being read.

#### **var**

- half2. Is only being read.

#### **delta**

- int. Is only being read.

**width**

- int. Is only being read.

**Returns**

Returns the 4-byte word referenced by var from the source thread ID as half2. If the source thread ID is out of range or the source thread has exited, the calling thread's own var is returned.

**Description**

Calculates a source thread ID by performing a bitwise XOR of the caller's thread ID with mask: the value of var held by the resulting thread ID is returned. If width is less than warpSize then each group of width consecutive threads are able to access elements from earlier groups of threads, however if they attempt to access elements from later groups of threads their own value of var will be returned. This mode implements a butterfly addressing pattern such as is used in tree reduction and broadcast.

**`__device__ __half __short2half_rd (short int i)`**

Convert a signed short integer to a half in round-down mode.

**Parameters**

**i**

- short int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the signed short integer value *i* to a half-precision floating point value in round-down mode. TBR

**`__device__ __half __short2half_rn (short int i)`**

Convert a signed short integer to a half in round-to-nearest-even mode.

**Parameters**

**i**

- short int. Is only being read.



**Returns**

half

- ▶ \p  
i converted to half.

**Description**

Convert the signed short integer value *i* to a half-precision floating point value in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half \_\_short2half\_ru (short int i)**

Convert a signed short integer to a half in round-up mode.

**Parameters**

- i**  
- short int. Is only being read.

**Returns**

half

- ▶ \p  
i converted to half.

**Description**

Convert the signed short integer value *i* to a half-precision floating point value in round-up mode. TBR

**\_\_device\_\_ \_\_half \_\_short2half\_rz (short int i)**

Convert a signed short integer to a half in round-towards-zero mode.

**Parameters**

- i**  
- short int. Is only being read.

**Returns**

half

- ▶ \p  
i converted to half.

**Description**

Convert the signed short integer value `i` to a half-precision floating point value in round-towards-zero mode. TBR

`__device__ __half __short_as_half (const short int i)`

Reinterprets bits in a signed short integer as a `half`.

**Parameters**

`i`

- short int. Is only being read.

**Returns**

`half`

- The  
reinterpreted value.

**Description**

Reinterprets the bits in the signed short integer `i` as a half-precision floating point number. TBR

`__device__ __half __uint2half_rd (unsigned int i)`

Convert an unsigned integer to a half in round-down mode.

**Parameters**

`i`

- unsigned int. Is only being read.

**Returns**

`half`

- `\p`  
`i` converted to half.

**Description**

Convert the unsigned integer value `i` to a half-precision floating point value in round-down mode. TBR

**\_\_device\_\_ \_\_half \_\_uint2half\_rn (unsigned int i)**

Convert an unsigned integer to a half in round-to-nearest-even mode.

**Parameters****i**

- unsigned int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the unsigned integer value *i* to a half-precision floating point value in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half \_\_uint2half\_ru (unsigned int i)**

Convert an unsigned integer to a half in round-up mode.

**Parameters****i**

- unsigned int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the unsigned integer value *i* to a half-precision floating point value in round-up mode. TBR

**\_\_device\_\_ \_\_half \_\_uint2half\_rz (unsigned int i)**

Convert an unsigned integer to a half in round-towards-zero mode.

**Parameters****i**

- unsigned int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the unsigned integer value *i* to a half-precision floating point value in round-towards-zero mode. TBR

**\_\_device\_\_ \_\_half \_\_ull2half\_rd (unsigned long long int i)**

Convert an unsigned 64-bit integer to a half in round-down mode.

**Parameters****i**

- unsigned long long int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the unsigned 64-bit integer value *i* to a half-precision floating point value in round-down mode. TBR

**\_\_device\_\_ \_\_half \_\_ull2half\_rn (unsigned long long int i)**

Convert an unsigned 64-bit integer to a half in round-to-nearest-even mode.

**Parameters****i**

- unsigned long long int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the unsigned 64-bit integer value *i* to a half-precision floating point value in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half \_\_ull2half\_ru (unsigned long long int i)**

Convert an unsigned 64-bit integer to a half in round-up mode.

**Parameters****i**

- unsigned long long int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the unsigned 64-bit integer value *i* to a half-precision floating point value in round-up mode. TBR

**\_\_device\_\_ \_\_half \_\_ull2half\_rz (unsigned long long int i)**

Convert an unsigned 64-bit integer to a half in round-towards-zero mode.

**Parameters****i**

- unsigned long long int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the unsigned 64-bit integer value *i* to a half-precision floating point value in round-towards-zero mode. TBR

**\_\_device\_\_ \_\_half \_\_ushort2half\_rd (unsigned short int i)**

Convert an unsigned short integer to a half in round-down mode.

**Parameters****i**

- unsigned short int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the unsigned short integer value *i* to a half-precision floating point value in round-down mode. TBR

**\_\_device\_\_ \_\_half \_\_ushort2half\_rn (unsigned short int i)**

Convert an unsigned short integer to a half in round-to-nearest-even mode.

**Parameters****i**

- unsigned short int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the unsigned short integer value *i* to a half-precision floating point value in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half \_\_ushort2half\_ru (unsigned short int i)**

Convert an unsigned short integer to a half in round-up mode.

**Parameters****i**

- unsigned short int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the unsigned short integer value *i* to a half-precision floating point value in round-up mode. TBR

**\_\_device\_\_ \_\_half \_\_ushort2half\_rz (unsigned short int i)**

Convert an unsigned short integer to a half in round-towards-zero mode.

**Parameters****i**

- unsigned short int. Is only being read.

**Returns**

half

► \p

i converted to half.

**Description**

Convert the unsigned short integer value *i* to a half-precision floating point value in round-towards-zero mode. TBR

**\_\_device\_\_ \_\_half \_\_ushort\_as\_half (const unsigned short int i)**

Reinterprets bits in an unsigned short integer as a `half`.

**Parameters****i**

- unsigned short int. Is only being read.

**Returns**

half

► The

reinterpreted value.

**Description**

Reinterprets the bits in the unsigned short integer *i* as a half-precision floating point number. TBR

## 1.1.6. Half Math Functions

Half Precision Intrinsics

To use these functions include the header file `cuda_fp16.h` in your program.



**\_\_device\_\_ \_\_half hceil (const \_\_half h)**

Calculate ceiling of the input argument.

### Parameters

**h**

- half. Is only being read.

### Returns

half

- The  
smallest integer value not less than h.

### Description

Compute the smallest integer value not less than h. TBR

**\_\_device\_\_ \_\_half hcos (const \_\_half a)**

Calculates half cosine in round-to-nearest-even mode.

### Parameters

**a**

- half. Is only being read.

### Returns

half

- The  
cosine of a.

### Description

Calculates half cosine of input a in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half hexp (const \_\_half a)**

Calculates half natural exponential function in round-to-nearest mode.

### Parameters

**a**

- half. Is only being read.

**Returns**

half

- The natural exponential function on a.

**Description**

Calculates `half` natural exponential function of input a in round-to-nearest-even mode.  
TBR

`__device__ __half hexp10 (const __half a)`

Calculates `half` decimal exponential function in round-to-nearest mode.

**Parameters**

- a**
- half. Is only being read.

**Returns**

half

- The decimal exponential function on a.

**Description**

Calculates `half` decimal exponential function of input a in round-to-nearest-even mode.  
TBR

`__device__ __half hexp2 (const __half a)`

Calculates `half` binary exponential function in round-to-nearest mode.

**Parameters**

- a**
- half. Is only being read.

**Returns**

half

- The binary exponential function on a.

**Description**

Calculates `half` binary exponential function of input `a` in round-to-nearest-even mode. TBR

`__device__ __half hfloor (const __half h)`

Calculate the largest integer less than or equal to `h`.

**Parameters**

**h**

- `half`. Is only being read.

**Returns**

`half`

► The

largest integer value which is less than or equal to `h`.

**Description**

Calculate the largest integer value which is less than or equal to `h`. TBR

`__device__ __half hlog (const __half a)`

Calculates `half` natural logarithm in round-to-nearest-even mode.

**Parameters**

**a**

- `half`. Is only being read.

**Returns**

`half`

► The

natural logarithm of `a`.

**Description**

Calculates `half` natural logarithm of input `a` in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half hlog10 (const \_\_half a)**

Calculates `half` decimal logarithm in round-to-nearest-even mode.

**Parameters**

**a**

- `half`. Is only being read.

**Returns**

`half`

- The decimal logarithm of `a`.

**Description**

Calculates `half` decimal logarithm of input `a` in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half hlog2 (const \_\_half a)**

Calculates `half` binary logarithm in round-to-nearest-even mode.

**Parameters**

**a**

- `half`. Is only being read.

**Returns**

`half`

- The binary logarithm of `a`.

**Description**

Calculates `half` binary logarithm of input `a` in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half hrcp (const \_\_half a)**

Calculates `half` reciprocal in round-to-nearest-even mode.

**Parameters**

**a**

- `half`. Is only being read.

**Returns**

half

- The reciprocal of a.

**Description**

Calculates `half` reciprocal of input `a` in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half hrint (const \_\_half h)**

Round input to nearest integer value in half-precision floating point number.

**Parameters**

**h**

- half. Is only being read.

**Returns**

half

- The nearest integer to h.

**Description**

Round `h` to the nearest integer value in half-precision floating point format, with halfway cases rounded to the nearest even integer value. TBR

**\_\_device\_\_ \_\_half hrsqrt (const \_\_half a)**

Calculates `half` reciprocal square root in round-to-nearest-even mode.

**Parameters**

**a**

- half. Is only being read.

**Returns**

half

- The reciprocal square root of a.

**Description**

Calculates `half` reciprocal square root of input `a` in round-to-nearest mode. TBR

`__device__ __half hsin (const __half a)`

Calculates `half` sine in round-to-nearest-even mode.

**Parameters**

`a`

- `half`. Is only being read.

**Returns**

`half`

- The  
sine of `a`.

**Description**

Calculates `half` sine of input `a` in round-to-nearest-even mode. TBR

`__device__ __half hsqrt (const __half a)`

Calculates `half` square root in round-to-nearest-even mode.

**Parameters**

`a`

- `half`. Is only being read.

**Returns**

`half`

- The  
square root of `a`.

**Description**

Calculates `half` square root of input `a` in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half htrunc (const \_\_half h)**

Truncate input argument to the integral part.

### Parameters

**h**

- half. Is only being read.

### Returns

half

- The truncated integer value.

### Description

Round *h* to the nearest integer value that does not exceed *h* in magnitude. TBR

## 1.1.7. Half2 Math Functions

Half Precision Intrinsics

To use these functions include the header file `cuda_fp16.h` in your program.

**\_\_device\_\_ \_\_half2 h2ceil (const \_\_half2 h)**

Calculate `half2` vector ceiling of the input argument.

### Parameters

**h**

- half2. Is only being read.

### Returns

half2

- The vector of smallest integers not less than *h*.

### Description

For each component of vector *h* compute the smallest integer value not less than *h*. TBR

**\_\_device\_\_ \_\_half2 h2cos (const \_\_half2 a)**

Calculates `half2` vector cosine in round-to-nearest-even mode.

**Parameters**

**a**

- `half2`. Is only being read.

**Returns**

`half2`

- The  
elementwise cosine on vector `a`.

**Description**

Calculates `half2` cosine of input vector `a` in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half2 h2exp (const \_\_half2 a)**

Calculates `half2` vector exponential function in round-to-nearest mode.

**Parameters**

**a**

- `half2`. Is only being read.

**Returns**

`half2`

- The  
elementwise exponential function on vector `a`.

**Description**

Calculates `half2` exponential function of input vector `a` in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half2 h2exp10 (const \_\_half2 a)**

Calculates `half2` vector decimal exponential function in round-to-nearest-even mode.

**Parameters**

**a**

- `half2`. Is only being read.



**Returns**

half2

- The  
elementwise decimal exponential function on vector a.

**Description**

Calculates `half2` decimal exponential function of input vector a in round-to-nearest-even mode. TBR

`__device__ __half2 h2exp2 (const __half2 a)`

Calculates `half2` vector binary exponential function in round-to-nearest-even mode.

**Parameters**

- a**
- half2. Is only being read.

**Returns**

half2

- The  
elementwise binary exponential function on vector a.

**Description**

Calculates `half2` binary exponential function of input vector a in round-to-nearest-even mode. TBR

`__device__ __half2 h2floor (const __half2 h)`

Calculate the largest integer less than or equal to h.

**Parameters**

- h**
- half2. Is only being read.

**Returns**

half2

- The  
vector of largest integers which is less than or equal to h.

**Description**

For each component of vector `h` calculate the largest integer value which is less than or equal to `h`. TBR

`__device__ __half2 h2log (const __half2 a)`

Calculates `half2` vector natural logarithm in round-to-nearest-even mode.

**Parameters**

**a**  
- `half2`. Is only being read.

**Returns**

`half2`

- The  
elementwise natural logarithm on vector `a`.

**Description**

Calculates `half2` natural logarithm of input vector `a` in round-to-nearest-even mode.  
TBR

`__device__ __half2 h2log10 (const __half2 a)`

Calculates `half2` vector decimal logarithm in round-to-nearest-even mode.

**Parameters**

**a**  
- `half2`. Is only being read.

**Returns**

`half2`

- The  
elementwise decimal logarithm on vector `a`.

**Description**

Calculates `half2` decimal logarithm of input vector `a` in round-to-nearest-even mode.  
TBR

**\_\_device\_\_ \_\_half2 h2log2 (const \_\_half2 a)**

Calculates `half2` vector binary logarithm in round-to-nearest-even mode.

**Parameters**

**a**

- `half2`. Is only being read.

**Returns**

`half2`

- The  
elementwise binary logarithm on vector `a`.

**Description**

Calculates `half2` binary logarithm of input vector `a` in round-to-nearest mode. TBR

**\_\_device\_\_ \_\_half2 h2rcp (const \_\_half2 a)**

Calculates `half2` vector reciprocal in round-to-nearest-even mode.

**Parameters**

**a**

- `half2`. Is only being read.

**Returns**

`half2`

- The  
elementwise reciprocal on vector `a`.

**Description**

Calculates `half2` reciprocal of input vector `a` in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half2 h2rint (const \_\_half2 h)**

Round input to nearest integer value in half-precision floating point number.

**Parameters**

**h**

- `half2`. Is only being read.

**Returns**

half2

- The  
vector of rounded integer values.

**Description**

Round each component of `half2` vector `h` to the nearest integer value in half-precision floating point format, with halfway cases rounded to the nearest even integer value. TBR

**\_\_device\_\_ \_\_half2 h2rsqrt (const \_\_half2 a)**

Calculates `half2` vector reciprocal square root in round-to-nearest mode.

**Parameters**

- a**  
- half2. Is only being read.

**Returns**

half2

- The  
elementwise reciprocal square root on vector `a`.

**Description**

Calculates `half2` reciprocal square root of input vector `a` in round-to-nearest-even mode. TBR

**\_\_device\_\_ \_\_half2 h2sin (const \_\_half2 a)**

Calculates `half2` vector sine in round-to-nearest-even mode.

**Parameters**

- a**  
- half2. Is only being read.

**Returns**

half2

- The  
elementwise sine on vector `a`.

**Description**

Calculates `half2` sine of input vector `a` in round-to-nearest-even mode. TBR

`__device__ __half2 h2sqrt (const __half2 a)`

Calculates `half2` vector square root in round-to-nearest-even mode.

**Parameters**

**a**

- `half2`. Is only being read.

**Returns**

`half2`

- The  
elementwise square root on vector `a`.

**Description**

Calculates `half2` square root of input vector `a` in round-to-nearest mode. TBR

`__device__ __half2 h2trunc (const __half2 h)`

Truncate `half2` vector input argument to the integral part.

**Parameters**

**h**

- `half2`. Is only being read.

**Returns**

`half2`

- The  
truncated `h`.

**Description**

Round each component of vector `h` to the nearest integer value that does not exceed `h` in magnitude. TBR

## 1.2. Mathematical Functions

CUDA mathematical functions are always available in device code. Some functions are also available in host code as indicated.

Note that floating-point functions are overloaded for different argument types. For example, the `log()` function has the following prototypes:

```
↑ double log(double x);
   float log(float x);
   float logf(float x);
```

## 1.3. Single Precision Mathematical Functions

This section describes single precision mathematical functions. To use these functions you do not need to include any additional header files in your program.

### `__device__ float acosf (float x)`

Calculate the arc cosine of the input argument.

#### Returns

Result will be in radians, in the interval  $[0, \pi]$  for  $x$  inside  $[-1, +1]$ .

- ▶ `acosf(1)` returns  $+0$ .
- ▶ `acosf(x)` returns NaN for  $x$  outside  $[-1, +1]$ .

#### Description

Calculate the principal value of the arc cosine of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

### `__device__ float acoshf (float x)`

Calculate the nonnegative arc hyperbolic cosine of the input argument.

#### Returns

Result will be in the interval  $[0, +\infty]$ .

- ▶ `acoshf(1)` returns  $0$ .
- ▶ `acoshf(x)` returns NaN for  $x$  in the interval  $[-\infty, 1)$ .

**Description**

Calculate the nonnegative arc hyperbolic cosine of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

**\_\_device\_\_ float asinf (float x)**

Calculate the arc sine of the input argument.

**Returns**

Result will be in radians, in the interval  $[-\pi/2, +\pi/2]$  for  $x$  inside  $[-1, +1]$ .

- ▶ `asinf(0)` returns +0.
- ▶ `asinf(x)` returns NaN for  $x$  outside  $[-1, +1]$ .

**Description**

Calculate the principal value of the arc sine of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

**\_\_device\_\_ float asinhf (float x)**

Calculate the arc hyperbolic sine of the input argument.

**Returns**

- ▶ `asinhf(0)` returns 1.

**Description**

Calculate the arc hyperbolic sine of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float atan2f (float y, float x)`

Calculate the arc tangent of the ratio of first and second input arguments.

### Returns

Result will be in radians, in the interval  $[-\pi, +\pi]$ .

- ▶ `atan2f(0, 1)` returns +0.

### Description

Calculate the principal value of the arc tangent of the ratio of first and second input arguments  $y / x$ . The quadrant of the result is determined by the signs of inputs  $y$  and  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float atanf (float x)`

Calculate the arc tangent of the input argument.

### Returns

Result will be in radians, in the interval  $[-\pi/2, +\pi/2]$ .

- ▶ `atanf(0)` returns +0.

### Description

Calculate the principal value of the arc tangent of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float atanhf (float x)`

Calculate the arc hyperbolic tangent of the input argument.

### Returns

- ▶ `atanhf(±0)` returns  $\pm 0$ .
- ▶ `atanhf(±1)` returns  $\pm \infty$ .
- ▶ `atanhf(x)` returns NaN for  $x$  outside interval  $[-1, 1]$ .



**Description**

Calculate the arc hyperbolic tangent of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

**\_\_device\_\_ float cbrtf (float x)**

Calculate the cube root of the input argument.

**Returns**

Returns  $x^{1/3}$ .

- ▶ `cbrtf(  $\pm 0$  )` returns  $\pm 0$ .
- ▶ `cbrtf(  $\pm \infty$  )` returns  $\pm \infty$ .

**Description**

Calculate the cube root of  $x$ ,  $x^{1/3}$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

**\_\_device\_\_ float ceilf (float x)**

Calculate ceiling of the input argument.

**Returns**

Returns  $\lceil x \rceil$  expressed as a floating-point number.

- ▶ `ceilf(  $\pm 0$  )` returns  $\pm 0$ .
- ▶ `ceilf(  $\pm \infty$  )` returns  $\pm \infty$ .

**Description**

Compute the smallest integer value not less than  $x$ .

## `__device__ float copysignf (float x, float y)`

Create value with given magnitude, copying sign of second value.

### Returns

Returns a value with the magnitude of  $x$  and the sign of  $y$ .

### Description

Create a floating-point value with the magnitude  $x$  and the sign of  $y$ .

## `__device__ float cosf (float x)`

Calculate the cosine of the input argument.

### Returns

- ▶ `cosf(0)` returns 1.
- ▶ `cosf(  $\pm \infty$  )` returns NaN.

### Description

Calculate the cosine of the input argument  $x$  (measured in radians).



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- ▶ This function is affected by the `--use_fast_math` compiler flag. See the CUDA C Programming Guide, Appendix D.2, Table 8 for a complete list of functions affected.

## `__device__ float coshf (float x)`

Calculate the hyperbolic cosine of the input argument.

### Returns

- ▶ `coshf(0)` returns 1.
- ▶ `coshf(  $\pm \infty$  )` returns NaN.

### Description

Calculate the hyperbolic cosine of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float cospif (float x)`

Calculate the cosine of the input argument  $\times \pi$ .

### Returns

- `cospif(  $\pm 0$  )` returns 1.
- `cospif(  $\pm \infty$  )` returns NaN.

### Description

Calculate the cosine of  $x \times \pi$  (measured in radians), where  $x$  is the input argument.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float cyl_bessel_i0f (float x)`

Calculate the value of the regular modified cylindrical Bessel function of order 0 for the input argument.

### Returns

Returns the value of the regular modified cylindrical Bessel function of order 0.

### Description

Calculate the value of the regular modified cylindrical Bessel function of order 0 for the input argument  $x$ ,  $I_0(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float cyl_bessel_i1f (float x)`

Calculate the value of the regular modified cylindrical Bessel function of order 1 for the input argument.

### Returns

Returns the value of the regular modified cylindrical Bessel function of order 1.

**Description**

Calculate the value of the regular modified cylindrical Bessel function of order 1 for the input argument  $x$ ,  $I_1(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

**\_\_device\_\_ float erfcf (float x)**

Calculate the complementary error function of the input argument.

**Returns**

- ▶  $\text{erfcf}(-\infty)$  returns 2.
- ▶  $\text{erfcf}(+\infty)$  returns +0.

**Description**

Calculate the complementary error function of the input argument  $x$ ,  $1 - \text{erf}(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

**\_\_device\_\_ float erfcinvf (float y)**

Calculate the inverse complementary error function of the input argument.

**Returns**

- ▶  $\text{erfcinvf}(0)$  returns  $+\infty$ .
- ▶  $\text{erfcinvf}(2)$  returns  $-\infty$ .

**Description**

Calculate the inverse complementary error function of the input argument  $y$ , for  $y$  in the interval  $[0, 2]$ . The inverse complementary error function find the value  $x$  that satisfies the equation  $y = \text{erfc}(x)$ , for  $0 \leq y \leq 2$ , and  $-\infty \leq x \leq \infty$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## \_\_device\_\_ float erfcxf (float x)

Calculate the scaled complementary error function of the input argument.

### Returns

- ▶  $\text{erfcxf}(-\infty)$  returns  $+\infty$
- ▶  $\text{erfcxf}(+\infty)$  returns  $+0$
- ▶  $\text{erfcxf}(x)$  returns  $+\infty$  if the correctly calculated value is outside the single floating point range.

### Description

Calculate the scaled complementary error function of the input argument  $x$ ,  $e^{x^2} \cdot \text{erfc}(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## \_\_device\_\_ float erff (float x)

Calculate the error function of the input argument.

### Returns

- ▶  $\text{erff}(\pm 0)$  returns  $\pm 0$ .
- ▶  $\text{erff}(\pm \infty)$  returns  $\pm 1$ .

### Description

Calculate the value of the error function for the input argument  $x$ ,  $\frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## \_\_device\_\_ float erfinvf (float y)

Calculate the inverse error function of the input argument.

### Returns

- ▶  $\text{erfinvf}(1)$  returns  $+\infty$ .
- ▶  $\text{erfinvf}(-1)$  returns  $-\infty$ .

**Description**

Calculate the inverse error function of the input argument  $y$ , for  $y$  in the interval  $[-1, 1]$ . The inverse error function finds the value  $x$  that satisfies the equation  $y = \text{erf}(x)$ , for  $-1 \leq y \leq 1$ , and  $-\infty \leq x \leq \infty$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

**\_\_device\_\_ float exp10f (float x)**

Calculate the base 10 exponential of the input argument.

**Returns**

Returns  $10^x$ .

**Description**

Calculate the base 10 exponential of the input argument  $x$ .



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- ▶ This function is affected by the `--use_fast_math` compiler flag. See the CUDA C Programming Guide, Appendix D.2, Table 8 for a complete list of functions affected.

**\_\_device\_\_ float exp2f (float x)**

Calculate the base 2 exponential of the input argument.

**Returns**

Returns  $2^x$ .

**Description**

Calculate the base 2 exponential of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float expf (float x)`

Calculate the base  $e$  exponential of the input argument.

### Returns

Returns  $e^x$ .

### Description

Calculate the base  $e$  exponential of the input argument  $x$ ,  $e^x$ .



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- ▶ This function is affected by the `--use_fast_math` compiler flag. See the CUDA C Programming Guide, Appendix D.2, Table 8 for a complete list of functions affected.

## `__device__ float expm1f (float x)`

Calculate the base  $e$  exponential of the input argument, minus 1.

### Returns

Returns  $e^x - 1$ .

### Description

Calculate the base  $e$  exponential of the input argument  $x$ , minus 1.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float fabsf (float x)`

Calculate the absolute value of its argument.

### Returns

Returns the absolute value of its argument.

- ▶ `fabsf( ±∞ )` returns  $+\infty$ .
- ▶ `fabsf( ±0 )` returns 0.

**Description**

Calculate the absolute value of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

**\_\_device\_\_ float fdimf (float x, float y)**

Compute the positive difference between  $x$  and  $y$ .

**Returns**

Returns the positive difference between  $x$  and  $y$ .

- ▶ `fdimf(x, y)` returns  $x - y$  if  $x > y$ .
- ▶ `fdimf(x, y)` returns  $+0$  if  $x \leq y$ .

**Description**

Compute the positive difference between  $x$  and  $y$ . The positive difference is  $x - y$  when  $x > y$  and  $+0$  otherwise.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

**\_\_device\_\_ float fdividef (float x, float y)**

Divide two floating point values.

**Returns**

Returns  $x / y$ .

**Description**

Compute  $x$  divided by  $y$ . If `--use_fast_math` is specified, use `__fdividef()` for higher performance, otherwise use normal division.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- ▶ This function is affected by the `--use_fast_math` compiler flag. See the CUDA C Programming Guide, Appendix D.2, Table 8 for a complete list of functions affected.



## `__device__ float floorf (float x)`

Calculate the largest integer less than or equal to  $x$ .

### Returns

Returns  $\log_e(1+x)$  expressed as a floating-point number.

- ▶ `floorf(  $\pm \infty$  )` returns  $\pm \infty$ .
- ▶ `floorf(  $\pm 0$  )` returns  $\pm 0$ .

### Description

Calculate the largest integer value which is less than or equal to  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float fmaf (float x, float y, float z)`

Compute  $x \times y + z$  as a single operation.

### Returns

Returns the rounded value of  $x \times y + z$  as a single operation.

- ▶ `fmaf(  $\pm \infty$ ,  $\pm 0$ ,  $z$  )` returns NaN.
- ▶ `fmaf(  $\pm 0$ ,  $\pm \infty$ ,  $z$  )` returns NaN.
- ▶ `fmaf( $x$ ,  $y$ ,  $-\infty$  )` returns NaN if  $x \times y$  is an exact  $+\infty$ .
- ▶ `fmaf( $x$ ,  $y$ ,  $+\infty$  )` returns NaN if  $x \times y$  is an exact  $-\infty$ .

### Description

Compute the value of  $x \times y + z$  as a single ternary operation. After computing the value to infinite precision, the value is rounded once.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float fmaxf (float x, float y)`

Determine the maximum numeric value of the arguments.

### Returns

Returns the maximum numeric values of the arguments  $x$  and  $y$ .

- ▶ If both arguments are NaN, returns NaN.
- ▶ If one argument is NaN, returns the numeric argument.

### Description

Determines the maximum numeric value of the arguments  $x$  and  $y$ . Treats NaN arguments as missing data. If one argument is a NaN and the other is legitimate numeric value, the numeric value is chosen.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float fminf (float x, float y)`

Determine the minimum numeric value of the arguments.

### Returns

Returns the minimum numeric values of the arguments  $x$  and  $y$ .

- ▶ If both arguments are NaN, returns NaN.
- ▶ If one argument is NaN, returns the numeric argument.

### Description

Determines the minimum numeric value of the arguments  $x$  and  $y$ . Treats NaN arguments as missing data. If one argument is a NaN and the other is legitimate numeric value, the numeric value is chosen.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float fmodf (float x, float y)`

Calculate the floating-point remainder of  $x / y$ .

### Returns

- ▶ Returns the floating point remainder of  $x / y$ .
- ▶ `fmodf(  $\pm 0$ , y )` returns  $\pm 0$  if  $y$  is not zero.
- ▶ `fmodf(x, y)` returns NaN and raised an invalid floating point exception if  $x$  is  $\pm \infty$  or  $y$  is zero.
- ▶ `fmodf(x, y)` returns zero if  $y$  is zero or the result would overflow.
- ▶ `fmodf(x,  $\pm \infty$ )` returns  $x$  if  $x$  is finite.
- ▶ `fmodf(x, 0)` returns NaN.

### Description

Calculate the floating-point remainder of  $x / y$ . The absolute value of the computed value is always less than  $y$ 's absolute value and will have the same sign as  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float frexpf (float x, int *nptr)`

Extract mantissa and exponent of a floating-point value.

### Returns

Returns the fractional component  $m$ .

- ▶ `frexpf(0, nptr)` returns 0 for the fractional component and zero for the integer component.
- ▶ `frexpf(  $\pm 0$ , nptr )` returns  $\pm 0$  and stores zero in the location pointed to by `nptr`.
- ▶ `frexpf(  $\pm \infty$ , nptr )` returns  $\pm \infty$  and stores an unspecified value in the location to which `nptr` points.
- ▶ `frexpf(NaN, y)` returns a NaN and stores an unspecified value in the location to which `nptr` points.

### Description

Decomposes the floating-point value  $x$  into a component  $m$  for the normalized fraction element and another term  $n$  for the exponent. The absolute value of  $m$  will be greater than or equal to 0.5 and less than 1.0 or it will be equal to 0;  $x = m \cdot 2^n$ . The integer exponent  $n$  will be stored in the location to which `nptr` points.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float __CRTDECL hypotf (float x, float y)`

Calculate the square root of the sum of squares of two arguments.

### Returns

Returns the length of the hypotenuse  $\sqrt{x^2 + y^2}$ . If the correct value would overflow, returns  $+\infty$ . If the correct value would underflow, returns 0.

### Description

Calculates the length of the hypotenuse of a right triangle whose two sides have lengths  $x$  and  $y$  without undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ int ilogbf (float x)`

Compute the unbiased integer exponent of the argument.

### Returns

- ▶ If successful, returns the unbiased exponent of the argument.
- ▶ `ilogbf(0)` returns `INT_MIN`.
- ▶ `ilogbf(NaN)` returns `NaN`.
- ▶ `ilogbf(x)` returns `INT_MAX` if  $x$  is  $\infty$  or the correct value is greater than `INT_MAX`.
- ▶ `ilogbf(x)` return `INT_MIN` if the correct value is less than `INT_MIN`.

### Description

Calculates the unbiased integer exponent of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ __RETURN_TYPE isfinite (float a)`

Determine whether argument is finite.

### Returns

- ▶ With Visual Studio 2013 host compiler: `__RETURN_TYPE` is 'bool'. Returns true if and only if `a` is a finite value.
- ▶ With other host compilers: `__RETURN_TYPE` is 'int'. Returns a nonzero value if and only if `a` is a finite value.

### Description

Determine whether the floating-point value `a` is a finite value (zero, subnormal, or normal and not infinity or NaN).

## `__device__ __RETURN_TYPE isinf (float a)`

Determine whether argument is infinite.

### Returns

- ▶ With Visual Studio 2013 host compiler: `__RETURN_TYPE` is 'bool'. Returns true if and only if `a` is a infinite value.
- ▶ With other host compilers: `__RETURN_TYPE` is 'int'. Returns a nonzero value if and only if `a` is a infinite value.

### Description

Determine whether the floating-point value `a` is an infinite value (positive or negative).

## `__device__ __RETURN_TYPE isnan (float a)`

Determine whether argument is a NaN.

### Returns

- ▶ With Visual Studio 2013 host compiler: `__RETURN_TYPE` is 'bool'. Returns true if and only if `a` is a NaN value.
- ▶ With other host compilers: `__RETURN_TYPE` is 'int'. Returns a nonzero value if and only if `a` is a NaN value.

### Description

Determine whether the floating-point value `a` is a NaN.

## `__device__ float j0f (float x)`

Calculate the value of the Bessel function of the first kind of order 0 for the input argument.

### Returns

Returns the value of the Bessel function of the first kind of order 0.

- ▶ `j0f( ± ∞ )` returns +0.
- ▶ `j0f(NaN)` returns NaN.

### Description

Calculate the value of the Bessel function of the first kind of order 0 for the input argument  $x$ ,  $J_0(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float j1f (float x)`

Calculate the value of the Bessel function of the first kind of order 1 for the input argument.

### Returns

Returns the value of the Bessel function of the first kind of order 1.

- ▶ `j1f( ± 0 )` returns  $\pm 0$ .
- ▶ `j1f( ± ∞ )` returns +0.
- ▶ `j1f(NaN)` returns NaN.

### Description

Calculate the value of the Bessel function of the first kind of order 1 for the input argument  $x$ ,  $J_1(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## \_\_device\_\_ float jnf (int n, float x)

Calculate the value of the Bessel function of the first kind of order  $n$  for the input argument.

### Returns

Returns the value of the Bessel function of the first kind of order  $n$ .

- ▶ `jnf(n, NaN)` returns NaN.
- ▶ `jnf(n, x)` returns NaN for  $n < 0$ .
- ▶ `jnf(n,  $+\infty$ )` returns +0.

### Description

Calculate the value of the Bessel function of the first kind of order  $n$  for the input argument  $x$ ,  $J_n(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## \_\_device\_\_ float ldexpf (float x, int exp)

Calculate the value of  $x \cdot 2^{exp}$ .

### Returns

- ▶ `ldexpf(x)` returns  $\pm \infty$  if the correctly calculated value is outside the single floating point range.

### Description

Calculate the value of  $x \cdot 2^{exp}$  of the input arguments  $x$  and  $exp$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## \_\_device\_\_ float lgammaf (float x)

Calculate the natural logarithm of the absolute value of the gamma function of the input argument.

### Returns

- ▶ `lgammaf(1)` returns +0.

- ▶ `lgammaf(2)` returns +0.
- ▶ `lgammaf(x)` returns  $\pm \infty$  if the correctly calculated value is outside the single floating point range.
- ▶ `lgammaf(x)` returns  $+\infty$  if  $x \leq 0$  and  $x$  is an integer.
- ▶ `lgammaf(-\infty)` returns  $-\infty$ .
- ▶ `lgammaf(+\infty)` returns  $+\infty$ .

### Description

Calculate the natural logarithm of the absolute value of the gamma function of the input argument  $x$ , namely the value of  $\log_e \left| \int_0^\infty e^{-t} t^{x-1} dt \right|$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ long long int llrintf (float x)`

Round input to nearest integer value.

### Returns

Returns rounded integer value.

### Description

Round  $x$  to the nearest integer value, with halfway cases rounded to the nearest even integer value. If the result is outside the range of the return type, the result is undefined.

## `__device__ long long int llroundf (float x)`

Round to nearest integer value.

### Returns

Returns rounded integer value.

### Description

Round  $x$  to the nearest integer value, with halfway cases rounded away from zero. If the result is outside the range of the return type, the result is undefined.



This function may be slower than alternate rounding methods. See `llrintf()`.



## \_\_device\_\_ float log10f (float x)

Calculate the base 10 logarithm of the input argument.

### Returns

- ▶  $\log_{10}f(\pm 0)$  returns  $-\infty$ .
- ▶  $\log_{10}f(1)$  returns +0.
- ▶  $\log_{10}f(x)$  returns NaN for  $x < 0$ .
- ▶  $\log_{10}f(+\infty)$  returns  $+\infty$ .

### Description

Calculate the base 10 logarithm of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## \_\_device\_\_ float log1pf (float x)

Calculate the value of  $\log_e(1+x)$ .

### Returns

- ▶  $\log_{1p}f(\pm 0)$  returns  $-\infty$ .
- ▶  $\log_{1p}f(-1)$  returns +0.
- ▶  $\log_{1p}f(x)$  returns NaN for  $x < -1$ .
- ▶  $\log_{1p}f(+\infty)$  returns  $+\infty$ .

### Description

Calculate the value of  $\log_e(1+x)$  of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## \_\_device\_\_ float log2f (float x)

Calculate the base 2 logarithm of the input argument.

### Returns

- ▶  $\log_2f(\pm 0)$  returns  $-\infty$ .
- ▶  $\log_2f(1)$  returns +0.

- ▶  $\log_2 f(x)$  returns NaN for  $x < 0$ .
- ▶  $\log_2 f(+\infty)$  returns  $+\infty$ .

### Description

Calculate the base 2 logarithm of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float logbf (float x)`

Calculate the floating point representation of the exponent of the input argument.

### Returns

- ▶  $\logbf(\pm 0)$  returns  $-\infty$
- ▶  $\logbf(+\infty)$  returns  $+\infty$

### Description

Calculate the floating point representation of the exponent of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float logf (float x)`

Calculate the natural logarithm of the input argument.

### Returns

- ▶  $\logf(\pm 0)$  returns  $-\infty$ .
- ▶  $\logf(1)$  returns +0.
- ▶  $\logf(x)$  returns NaN for  $x < 0$ .
- ▶  $\logf(+\infty)$  returns  $+\infty$ .

### Description

Calculate the natural logarithm of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ long int lrintf (float x)`

Round input to nearest integer value.

### Returns

Returns rounded integer value.

### Description

Round  $x$  to the nearest integer value, with halfway cases rounded to the nearest even integer value. If the result is outside the range of the return type, the result is undefined.

## `__device__ long int lroundf (float x)`

Round to nearest integer value.

### Returns

Returns rounded integer value.

### Description

Round  $x$  to the nearest integer value, with halfway cases rounded away from zero. If the result is outside the range of the return type, the result is undefined.



This function may be slower than alternate rounding methods. See [lrintf\(\)](#).

## `__device__ float modff (float x, float *iptr)`

Break down the input argument into fractional and integral parts.

### Returns

- ▶ `modff(  $\pm x$ , iptr)` returns a result with the same sign as  $x$ .
- ▶ `modff(  $\pm \infty$ , iptr)` returns  $\pm 0$  and stores  $\pm \infty$  in the object pointed to by `iptr`.
- ▶ `modff(NaN, iptr)` stores a NaN in the object pointed to by `iptr` and returns a NaN.

### Description

Break down the argument  $x$  into fractional and integral parts. The integral part is stored in the argument `iptr`. Fractional and integral parts are given the same sign as the argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float nanf (const char *tagp)`

Returns "Not a Number" value.

### Returns

- `nanf(tagp)` returns NaN.

### Description

Return a representation of a quiet NaN. Argument `tagp` selects one of the possible representations.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float nearbyintf (float x)`

Round the input argument to the nearest integer.

### Returns

- `nearbyintf( ± 0 )` returns  $\pm 0$ .
- `nearbyintf( ± ∞ )` returns  $\pm \infty$ .

### Description

Round argument  $x$  to an integer value in single precision floating-point format.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float nextafterf (float x, float y)`

Return next representable single-precision floating-point value after argument.

### Returns

- `nextafterf( ± ∞ , y )` returns  $\pm \infty$ .

## Description

Calculate the next representable single-precision floating-point value following  $x$  in the direction of  $y$ . For example, if  $y$  is greater than  $x$ , `nextafterf()` returns the smallest representable number greater than  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float norm3df (float a, float b, float c)`

Calculate the square root of the sum of squares of three coordinates of the argument.

## Returns

Returns the length of the 3D  $\sqrt{p.x^2 + p.y^2 + p.z^2}$ . If the correct value would overflow, returns  $+\infty$ . If the correct value would underflow, returns 0.

## Description

Calculates the length of three dimensional vector  $p$  in euclidean space without undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float norm4df (float a, float b, float c, float d)`

Calculate the square root of the sum of squares of four coordinates of the argument.

## Returns

Returns the length of the 4D vector  $\sqrt{p.x^2 + p.y^2 + p.z^2 + p.t^2}$ . If the correct value would overflow, returns  $+\infty$ . If the correct value would underflow, returns 0.

## Description

Calculates the length of four dimensional vector  $p$  in euclidean space without undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float normcdf (float y)`

Calculate the standard normal cumulative distribution function.

### Returns

- ▶ `normcdf(+∞)` returns 1
- ▶ `normcdf(-∞)` returns +0

### Description

Calculate the cumulative distribution function of the standard normal distribution for input argument  $y$ ,  $\Phi(y)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float normcdfinvf (float y)`

Calculate the inverse of the standard normal cumulative distribution function.

### Returns

- ▶ `normcdfinvf(0)` returns  $-\infty$ .
- ▶ `normcdfinvf(1)` returns  $+\infty$ .
- ▶ `normcdfinvf(x)` returns NaN if  $x$  is not in the interval  $[0,1]$ .

### Description

Calculate the inverse of the standard normal cumulative distribution function for input argument  $y$ ,  $\Phi^{-1}(y)$ . The function is defined for input values in the interval  $(0, 1)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float normf (int dim, const float *a)`

Calculate the square root of the sum of squares of any number of coordinates.

### Returns

Returns the length of the vector  $\sqrt{p.1^2 + p.2^2 + \dots + p.\text{dim}^2}$ . If the correct value would overflow, returns  $+\infty$ . If the correct value would underflow, returns 0.

## Description

Calculates the length of a vector  $p$ , dimension of which is passed as an argument without undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float powf (float x, float y)`

Calculate the value of first argument to the power of second argument.

## Returns

- ▶ `powf( ±0, y)` returns  $±∞$  for  $y$  an integer less than 0.
- ▶ `powf( ±0, y)` returns  $±0$  for  $y$  an odd integer greater than 0.
- ▶ `powf( ±0, y)` returns  $+0$  for  $y > 0$  and not an odd integer.
- ▶ `powf(-1, ±∞)` returns 1.
- ▶ `powf(+1, y)` returns 1 for any  $y$ , even a NaN.
- ▶ `powf(x, ±0)` returns 1 for any  $x$ , even a NaN.
- ▶ `powf(x, y)` returns a NaN for finite  $x < 0$  and finite non-integer  $y$ .
- ▶ `powf(x, -∞)` returns  $+∞$  for  $|x| < 1$ .
- ▶ `powf(x, -∞)` returns  $+0$  for  $|x| > 1$ .
- ▶ `powf(x, +∞)` returns  $+0$  for  $|x| < 1$ .
- ▶ `powf(x, +∞)` returns  $+∞$  for  $|x| > 1$ .
- ▶ `powf( -∞, y)` returns  $-0$  for  $y$  an odd integer less than 0.
- ▶ `powf( -∞, y)` returns  $+0$  for  $y < 0$  and not an odd integer.
- ▶ `powf( -∞, y)` returns  $-∞$  for  $y$  an odd integer greater than 0.
- ▶ `powf( -∞, y)` returns  $+∞$  for  $y > 0$  and not an odd integer.
- ▶ `powf( +∞, y)` returns  $+0$  for  $y < 0$ .
- ▶ `powf( +∞, y)` returns  $+∞$  for  $y > 0$ .

## Description

Calculate the value of  $x$  to the power of  $y$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float rcbtrf (float x)`

Calculate reciprocal cube root function.

### Returns

- `rcbtrf(  $\pm 0$  )` returns  $\pm \infty$ .
- `rcbtrf(  $\pm \infty$  )` returns  $\pm 0$ .

### Description

Calculate reciprocal cube root function of  $x$



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float remainderf (float x, float y)`

Compute single-precision floating-point remainder.

### Returns

- `remainderf(x, 0)` returns NaN.
- `remainderf(  $\pm \infty$ ,  $y$  )` returns NaN.
- `remainderf(x,  $\pm \infty$  )` returns  $x$  for finite  $x$ .

### Description

Compute single-precision floating-point remainder  $r$  of dividing  $x$  by  $y$  for nonzero  $y$ .

Thus  $r = x - ny$ . The value  $n$  is the integer value nearest  $\frac{x}{y}$ . In the case when  $|n - \frac{x}{y}| = \frac{1}{2}$ , the even  $n$  value is chosen.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float remquof (float x, float y, int *quo)`

Compute single-precision floating-point remainder and part of quotient.

### Returns

Returns the remainder.

- `remquof(x, 0, quo)` returns NaN.



- ▶ `remquof(  $\pm \infty$ , y, quo)` returns NaN.
- ▶ `remquof(x,  $\pm \infty$ , quo)` returns x.

### Description

Compute a double-precision floating-point remainder in the same way as the `remainderf()` function. Argument `quo` returns part of quotient upon division of `x` by `y`. Value `quo` has the same sign as  $\frac{x}{y}$  and may not be the exact quotient but agrees with the exact quotient in the low order 3 bits.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float rhypotf (float x, float y)`

Calculate one over the square root of the sum of squares of two arguments.

### Returns

Returns one over the length of the hypotenuse  $\frac{1}{\sqrt{x^2 + y^2}}$ . If the square root would overflow, returns 0. If the square root would underflow, returns  $+\infty$ .

### Description

Calculates one over the length of the hypotenuse of a right triangle whose two sides have lengths `x` and `y` without undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float rintf (float x)`

Round input to nearest integer value in floating-point.

### Returns

Returns rounded integer value.

### Description

Round `x` to the nearest integer value in floating-point format, with halfway cases rounded to the nearest even integer value.

## `__device__ float rnorm3df (float a, float b, float c)`

Calculate one over the square root of the sum of squares of three coordinates of the argument.

### Returns

Returns one over the length of the 3D vector  $\frac{1}{\sqrt{p.x^2 + p.y^2 + p.z^2}}$ . If the square root would overflow, returns 0. If the square root would underflow, returns  $+\infty$ .

### Description

Calculates one over the length of three dimension vector  $p$  in euclidean space without undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float rnorm4df (float a, float b, float c, float d)`

Calculate one over the square root of the sum of squares of four coordinates of the argument.

### Returns

Returns one over the length of the 4D vector  $\frac{1}{\sqrt{p.x^2 + p.y^2 + p.z^2 + p.w^2}}$ . If the square root would overflow, returns 0. If the square root would underflow, returns  $+\infty$ .

### Description

Calculates one over the length of four dimension vector  $p$  in euclidean space without undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float rnormf (int dim, const float *a)`

Calculate the reciprocal of square root of the sum of squares of any number of coordinates.

### Returns

Returns one over the length of the vector  $\frac{1}{\sqrt{p.1^2 + p.2^2 + \dots + p.\text{dim}^2}}$ . If the square root would overflow, returns 0. If the square root would underflow, returns  $+\infty$ .

### Description

Calculates one over the length of vector  $p$ , dimension of which is passed as an argument, in euclidean space without undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float roundf (float x)`

Round to nearest integer value in floating-point.

### Returns

Returns rounded integer value.

### Description

Round  $x$  to the nearest integer value in floating-point format, with halfway cases rounded away from zero.



This function may be slower than alternate rounding methods. See [rintf\(\)](#).

## `__device__ float rsqrtf (float x)`

Calculate the reciprocal of the square root of the input argument.

### Returns

Returns  $1/\sqrt{x}$ .

- ▶ `rsqrtf( +∞ )` returns  $+0$ .
- ▶ `rsqrtf( ±0 )` returns  $±∞$ .

- ▶ `rsqrtf(x)` returns NaN if  $x$  is less than 0.

### Description

Calculate the reciprocal of the nonnegative square root of  $x$ ,  $1/\sqrt{x}$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float scalblnf (float x, long int n)`

Scale floating-point input by integer power of two.

### Returns

Returns  $x * 2^n$ .

- ▶ `scalblnf( ±0, n)` returns  $\pm 0$ .
- ▶ `scalblnf(x, 0)` returns  $x$ .
- ▶ `scalblnf( ±∞, n)` returns  $\pm \infty$ .

### Description

Scale  $x$  by  $2^n$  by efficient manipulation of the floating-point exponent.

## `__device__ float scalbnf (float x, int n)`

Scale floating-point input by integer power of two.

### Returns

Returns  $x * 2^n$ .

- ▶ `scalbnf( ±0, n)` returns  $\pm 0$ .
- ▶ `scalbnf(x, 0)` returns  $x$ .
- ▶ `scalbnf( ±∞, n)` returns  $\pm \infty$ .

### Description

Scale  $x$  by  $2^n$  by efficient manipulation of the floating-point exponent.

## `__device__ __RETURN_TYPE signbit (float a)`

Return the sign bit of the input.

### Returns

Reports the sign bit of all values including infinities, zeros, and NaNs.

- ▶ With Visual Studio 2013 host compiler: `__RETURN_TYPE` is 'bool'. Returns true if and only if `a` is negative.
- ▶ With other host compilers: `__RETURN_TYPE` is 'int'. Returns a nonzero value if and only if `a` is negative.

### Description

Determine whether the floating-point value `a` is negative.

## `__device__ void sincosf (float x, float *sptr, float *cptr)`

Calculate the sine and cosine of the first input argument.

### Returns

- ▶ none

### Description

Calculate the sine and cosine of the first input argument `x` (measured in radians). The results for sine and cosine are written into the second argument, `sptr`, and, respectively, third argument, `cptr`.

### See also:

`sinf()` and `cosf()`.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- ▶ This function is affected by the `--use_fast_math` compiler flag. See the CUDA C Programming Guide, Appendix D.2, Table 8 for a complete list of functions affected.

## `__device__ void sincospif (float x, float *sptr, float *cptr)`

Calculate the sine and cosine of the first input argument  $\times \pi$ .

### Returns

- ▶ none

### Description

Calculate the sine and cosine of the first input argument,  $x$  (measured in radians),  $\times \pi$ . The results for sine and cosine are written into the second argument, `sptr`, and, respectively, third argument, `cptr`.

### See also:

`sinpif()` and `cospif()`.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float sinf (float x)`

Calculate the sine of the input argument.

### Returns

- ▶ `sinf(  $\pm 0$  )` returns  $\pm 0$ .
- ▶ `sinf(  $\pm \infty$  )` returns NaN.

### Description

Calculate the sine of the input argument  $x$  (measured in radians).



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- ▶ This function is affected by the `--use_fast_math` compiler flag. See the CUDA C Programming Guide, Appendix D.2, Table 8 for a complete list of functions affected.

## `__device__ float sinhf (float x)`

Calculate the hyperbolic sine of the input argument.

### Returns

- ▶ `sinhf(  $\pm 0$  )` returns  $\pm 0$ .
- ▶ `sinhf(  $\pm \infty$  )` returns NaN.

### Description

Calculate the hyperbolic sine of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float sinpif (float x)`

Calculate the sine of the input argument  $\times \pi$ .

### Returns

- ▶ `sinpif(  $\pm 0$  )` returns  $\pm 0$ .
- ▶ `sinpif(  $\pm \infty$  )` returns NaN.

### Description

Calculate the sine of  $x \times \pi$  (measured in radians), where  $x$  is the input argument.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float sqrtf (float x)`

Calculate the square root of the input argument.

### Returns

Returns  $\sqrt{x}$ .

- ▶ `sqrtf(  $\pm 0$  )` returns  $\pm 0$ .
- ▶ `sqrtf(  $+\infty$  )` returns  $+\infty$ .
- ▶ `sqrtf(x)` returns NaN if  $x$  is less than 0.

**Description**

Calculate the nonnegative square root of  $x$ ,  $\sqrt{x}$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

**\_\_device\_\_ float tanf (float x)**

Calculate the tangent of the input argument.

**Returns**

- ▶  $\text{tanf}(\pm 0)$  returns  $\pm 0$ .
- ▶  $\text{tanf}(\pm \infty)$  returns NaN.

**Description**

Calculate the tangent of the input argument  $x$  (measured in radians).



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- ▶ This function is affected by the `--use_fast_math` compiler flag. See the CUDA C Programming Guide, Appendix D.2, Table 8 for a complete list of functions affected.

**\_\_device\_\_ float tanhf (float x)**

Calculate the hyperbolic tangent of the input argument.

**Returns**

- ▶  $\text{tanhf}(\pm 0)$  returns  $\pm 0$ .

**Description**

Calculate the hyperbolic tangent of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.



## `__device__ float tgammaf (float x)`

Calculate the gamma function of the input argument.

### Returns

- ▶ `tgammaf( ± 0 )` returns  $\pm \infty$ .
- ▶ `tgammaf(2)` returns +1.
- ▶ `tgammaf(x)` returns  $\pm \infty$  if the correctly calculated value is outside the single floating point range.
- ▶ `tgammaf(x)` returns NaN if  $x < 0$  and  $x$  is an integer.
- ▶ `tgammaf( - ∞ )` returns NaN.
- ▶ `tgammaf( + ∞ )` returns  $+\infty$ .

### Description

Calculate the gamma function of the input argument  $x$ , namely the value of  $\int_0^\infty e^{-t} t^{x-1} dt$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float truncf (float x)`

Truncate input argument to the integral part.

### Returns

Returns truncated integer value.

### Description

Round  $x$  to the nearest integer value that does not exceed  $x$  in magnitude.

## `__device__ float y0f (float x)`

Calculate the value of the Bessel function of the second kind of order 0 for the input argument.

### Returns

Returns the value of the Bessel function of the second kind of order 0.

- ▶ `y0f(0)` returns  $-\infty$ .
- ▶ `y0f(x)` returns NaN for  $x < 0$ .
- ▶ `y0f( + ∞ )` returns +0.

- ▶ `y0f(NaN)` returns NaN.

### Description

Calculate the value of the Bessel function of the second kind of order 0 for the input argument  $x$ ,  $Y_0(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float y1f (float x)`

Calculate the value of the Bessel function of the second kind of order 1 for the input argument.

### Returns

Returns the value of the Bessel function of the second kind of order 1.

- ▶ `y1f(0)` returns  $-\infty$ .
- ▶ `y1f(x)` returns NaN for  $x < 0$ .
- ▶ `y1f(+∞)` returns +0.
- ▶ `y1f(NaN)` returns NaN.

### Description

Calculate the value of the Bessel function of the second kind of order 1 for the input argument  $x$ ,  $Y_1(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float ynf (int n, float x)`

Calculate the value of the Bessel function of the second kind of order  $n$  for the input argument.

### Returns

Returns the value of the Bessel function of the second kind of order  $n$ .

- ▶ `ynf(n, x)` returns NaN for  $n < 0$ .
- ▶ `ynf(n, 0)` returns  $-\infty$ .
- ▶ `ynf(n, x)` returns NaN for  $x < 0$ .
- ▶ `ynf(n, +∞)` returns +0.

- ▶ `ynf(n, NaN)` returns NaN.

### Description

Calculate the value of the Bessel function of the second kind of order  $n$  for the input argument  $x$ ,  $Y_n(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## 1.4. Double Precision Mathematical Functions

This section describes double precision mathematical functions. To use these functions you do not need to include any additional header files in your program.

### `__device__ double acos (double x)`

Calculate the arc cosine of the input argument.

#### Returns

Result will be in radians, in the interval  $[0, \pi]$  for  $x$  inside  $[-1, +1]$ .

- ▶ `acos(1)` returns +0.
- ▶ `acos(x)` returns NaN for  $x$  outside  $[-1, +1]$ .

### Description

Calculate the principal value of the arc cosine of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

### `__device__ double acosh (double x)`

Calculate the nonnegative arc hyperbolic cosine of the input argument.

#### Returns

Result will be in the interval  $[0, +\infty]$ .

- ▶ `acosh(1)` returns 0.
- ▶ `acosh(x)` returns NaN for  $x$  in the interval  $[-\infty, 1)$ .

**Description**

Calculate the nonnegative arc hyperbolic cosine of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ double asin (double x)**

Calculate the arc sine of the input argument.

**Returns**

Result will be in radians, in the interval  $[-\pi/2, +\pi/2]$  for  $x$  inside  $[-1, +1]$ .

- ▶ `asin(0)` returns +0.
- ▶ `asin(x)` returns NaN for  $x$  outside  $[-1, +1]$ .

**Description**

Calculate the principal value of the arc sine of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ double asinh (double x)**

Calculate the arc hyperbolic sine of the input argument.

**Returns**

- ▶ `asinh(0)` returns 1.

**Description**

Calculate the arc hyperbolic sine of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double atan (double x)`

Calculate the arc tangent of the input argument.

### Returns

Result will be in radians, in the interval  $[-\pi/2, +\pi/2]$ .

- ▶ `atan(0)` returns +0.

### Description

Calculate the principal value of the arc tangent of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double atan2 (double y, double x)`

Calculate the arc tangent of the ratio of first and second input arguments.

### Returns

Result will be in radians, in the interval  $[-\pi, +\pi]$ .

- ▶ `atan2(0, 1)` returns +0.

### Description

Calculate the principal value of the arc tangent of the ratio of first and second input arguments  $y/x$ . The quadrant of the result is determined by the signs of inputs  $y$  and  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double atanh (double x)`

Calculate the arc hyperbolic tangent of the input argument.

### Returns

- ▶ `atanh( $\pm 0$ )` returns  $\pm 0$ .
- ▶ `atanh( $\pm 1$ )` returns  $\pm \infty$ .
- ▶ `atanh( $x$ )` returns NaN for  $x$  outside interval  $[-1, 1]$ .

**Description**

Calculate the arc hyperbolic tangent of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ double cbrt (double x)**

Calculate the cube root of the input argument.

**Returns**

Returns  $x^{1/3}$ .

- ▶ `cbrt(  $\pm 0$  )` returns  $\pm 0$ .
- ▶ `cbrt(  $\pm \infty$  )` returns  $\pm \infty$ .

**Description**

Calculate the cube root of  $x$ ,  $x^{1/3}$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ \_\_CUDA\_MATH\_CRTIMP double ceil (double x)**

Calculate ceiling of the input argument.

**Returns**

Returns  $\lceil x \rceil$  expressed as a floating-point number.

- ▶ `ceil(  $\pm 0$  )` returns  $\pm 0$ .
- ▶ `ceil(  $\pm \infty$  )` returns  $\pm \infty$ .

**Description**

Compute the smallest integer value not less than  $x$ .

## `__device__ double copysign (double x, double y)`

Create value with given magnitude, copying sign of second value.

### Returns

Returns a value with the magnitude of  $x$  and the sign of  $y$ .

### Description

Create a floating-point value with the magnitude  $x$  and the sign of  $y$ .

## `__device__ double cos (double x)`

Calculate the cosine of the input argument.

### Returns

- ▶  $\cos(\pm 0)$  returns 1.
- ▶  $\cos(\pm \infty)$  returns NaN.

### Description

Calculate the cosine of the input argument  $x$  (measured in radians).



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double cosh (double x)`

Calculate the hyperbolic cosine of the input argument.

### Returns

- ▶  $\cosh(0)$  returns 1.
- ▶  $\cosh(\pm \infty)$  returns  $+\infty$ .

### Description

Calculate the hyperbolic cosine of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double cospi (double x)`

Calculate the cosine of the input argument  $\times \pi$ .

### Returns

- ▶ `cospi(  $\pm 0$  )` returns 1.
- ▶ `cospi(  $\pm \infty$  )` returns NaN.

### Description

Calculate the cosine of  $x \times \pi$  (measured in radians), where  $x$  is the input argument.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ __CUDA_MATH_CRTIMP double cyl_bessel_i0 (double x)`

Calculate the value of the regular modified cylindrical Bessel function of order 0 for the input argument.

### Returns

Returns the value of the regular modified cylindrical Bessel function of order 0.

### Description

Calculate the value of the regular modified cylindrical Bessel function of order 0 for the input argument  $x$ ,  $I_0(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ __CUDA_MATH_CRTIMP double cyl_bessel_i1 (double x)`

Calculate the value of the regular modified cylindrical Bessel function of order 1 for the input argument.

### Returns

Returns the value of the regular modified cylindrical Bessel function of order 1.



**Description**

Calculate the value of the regular modified cylindrical Bessel function of order 1 for the input argument  $x$ ,  $I_1(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ double erf (double x)**

Calculate the error function of the input argument.

**Returns**

- ▶  $\text{erf}(\pm 0)$  returns  $\pm 0$ .
- ▶  $\text{erf}(\pm \infty)$  returns  $\pm 1$ .

**Description**

Calculate the value of the error function for the input argument  $x$ ,  $\frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ double erfc (double x)**

Calculate the complementary error function of the input argument.

**Returns**

- ▶  $\text{erfc}(-\infty)$  returns 2.
- ▶  $\text{erfc}(+\infty)$  returns +0.

**Description**

Calculate the complementary error function of the input argument  $x$ ,  $1 - \text{erf}(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double erfcinv (double y)`

Calculate the inverse complementary error function of the input argument.

### Returns

- ▶ `erfcinv(0)` returns  $+\infty$ .
- ▶ `erfcinv(2)` returns  $-\infty$ .

### Description

Calculate the inverse complementary error function of the input argument  $y$ , for  $y$  in the interval  $[0, 2]$ . The inverse complementary error function find the value  $x$  that satisfies the equation  $y = \operatorname{erfc}(x)$ , for  $0 \leq y \leq 2$ , and  $-\infty \leq x \leq \infty$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double erfcx (double x)`

Calculate the scaled complementary error function of the input argument.

### Returns

- ▶ `erfcx(-∞)` returns  $+\infty$
- ▶ `erfcx(+∞)` returns  $+0$
- ▶ `erfcx(x)` returns  $+\infty$  if the correctly calculated value is outside the double floating point range.

### Description

Calculate the scaled complementary error function of the input argument  $x$ ,  $e^{x^2} \cdot \operatorname{erfc}(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double erfinv (double y)`

Calculate the inverse error function of the input argument.

### Returns

- ▶ `erfinv(1)` returns  $+\infty$ .
- ▶ `erfinv(-1)` returns  $-\infty$ .

**Description**

Calculate the inverse error function of the input argument  $y$ , for  $y$  in the interval  $[-1, 1]$ . The inverse error function finds the value  $x$  that satisfies the equation  $y = \text{erf}(x)$ , for  $-1 \leq y \leq 1$ , and  $-\infty \leq x \leq \infty$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ double exp (double x)**

Calculate the base  $e$  exponential of the input argument.

**Returns**

Returns  $e^x$ .

**Description**

Calculate the base  $e$  exponential of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ double exp10 (double x)**

Calculate the base 10 exponential of the input argument.

**Returns**

Returns  $10^x$ .

**Description**

Calculate the base 10 exponential of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double exp2 (double x)`

Calculate the base 2 exponential of the input argument.

### Returns

Returns  $2^x$ .

### Description

Calculate the base 2 exponential of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double expm1 (double x)`

Calculate the base  $e$  exponential of the input argument, minus 1.

### Returns

Returns  $e^x - 1$ .

### Description

Calculate the base  $e$  exponential of the input argument  $x$ , minus 1.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double fabs (double x)`

Calculate the absolute value of the input argument.

### Returns

Returns the absolute value of the input argument.

- ▶ `fabs(  $\pm \infty$  )` returns  $+\infty$ .
- ▶ `fabs(  $\pm 0$  )` returns 0.

### Description

Calculate the absolute value of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double fdim (double x, double y)`

Compute the positive difference between  $x$  and  $y$ .

### Returns

Returns the positive difference between  $x$  and  $y$ .

- ▶ `fdim(x, y)` returns  $x - y$  if  $x > y$ .
- ▶ `fdim(x, y)` returns  $+0$  if  $x \leq y$ .

### Description

Compute the positive difference between  $x$  and  $y$ . The positive difference is  $x - y$  when  $x > y$  and  $+0$  otherwise.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ __CUDA_MATH_CRTIMP double floor (double x)`

Calculate the largest integer less than or equal to  $x$ .

### Returns

Returns  $\log_e(1+x)$  expressed as a floating-point number.

- ▶ `floor(  $\pm \infty$  )` returns  $\pm \infty$ .
- ▶ `floor(  $\pm 0$  )` returns  $\pm 0$ .

### Description

Calculates the largest integer value which is less than or equal to  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double fma (double x, double y, double z)`

Compute  $x \times y + z$  as a single operation.

### Returns

Returns the rounded value of  $x \times y + z$  as a single operation.

- ▶ `fma(  $\pm \infty$ ,  $\pm 0$ ,  $z$  )` returns NaN.
- ▶ `fma(  $\pm 0$ ,  $\pm \infty$ ,  $z$  )` returns NaN.
- ▶ `fma( $x$ ,  $y$ ,  $-\infty$ )` returns NaN if  $x \times y$  is an exact  $+\infty$ .
- ▶ `fma( $x$ ,  $y$ ,  $+\infty$ )` returns NaN if  $x \times y$  is an exact  $-\infty$ .

### Description

Compute the value of  $x \times y + z$  as a single ternary operation. After computing the value to infinite precision, the value is rounded once.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double fmax (double, double)`

Determine the maximum numeric value of the arguments.

### Returns

Returns the maximum numeric values of the arguments  $x$  and  $y$ .

- ▶ If both arguments are NaN, returns NaN.
- ▶ If one argument is NaN, returns the numeric argument.

### Description

Determines the maximum numeric value of the arguments  $x$  and  $y$ . Treats NaN arguments as missing data. If one argument is a NaN and the other is legitimate numeric value, the numeric value is chosen.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double fmin (double x, double y)`

Determine the minimum numeric value of the arguments.

### Returns

Returns the minimum numeric values of the arguments  $x$  and  $y$ .

- ▶ If both arguments are NaN, returns NaN.
- ▶ If one argument is NaN, returns the numeric argument.

### Description

Determines the minimum numeric value of the arguments  $x$  and  $y$ . Treats NaN arguments as missing data. If one argument is a NaN and the other is legitimate numeric value, the numeric value is chosen.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double fmod (double x, double y)`

Calculate the floating-point remainder of  $x / y$ .

### Returns

- ▶ Returns the floating point remainder of  $x / y$ .
- ▶  $\text{fmod}(\pm 0, y)$  returns  $\pm 0$  if  $y$  is not zero.
- ▶  $\text{fmod}(x, y)$  returns NaN and raised an invalid floating point exception if  $x$  is  $\pm \infty$  or  $y$  is zero.
- ▶  $\text{fmod}(x, y)$  returns zero if  $y$  is zero or the result would overflow.
- ▶  $\text{fmod}(x, \pm \infty)$  returns  $x$  if  $x$  is finite.
- ▶  $\text{fmod}(x, 0)$  returns NaN.

### Description

Calculate the floating-point remainder of  $x / y$ . The absolute value of the computed value is always less than  $y$ 's absolute value and will have the same sign as  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ __CUDA_MATH_CRTIMP double frexp (double x, int *nptr)`

Extract mantissa and exponent of a floating-point value.

### Returns

Returns the fractional component  $m$ .

- ▶ `frexp(0, nptr)` returns 0 for the fractional component and zero for the integer component.
- ▶ `frexp( $\pm 0$ , nptr)` returns  $\pm 0$  and stores zero in the location pointed to by `nptr`.
- ▶ `frexp( $\pm \infty$ , nptr)` returns  $\pm \infty$  and stores an unspecified value in the location to which `nptr` points.
- ▶ `frexp(NaN, y)` returns a NaN and stores an unspecified value in the location to which `nptr` points.

### Description

Decompose the floating-point value  $x$  into a component  $m$  for the normalized fraction element and another term  $n$  for the exponent. The absolute value of  $m$  will be greater than or equal to 0.5 and less than 1.0 or it will be equal to 0;  $x = m \cdot 2^n$ . The integer exponent  $n$  will be stored in the location to which `nptr` points.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ __ACRTIMP double hypot (double x, double y)`

Calculate the square root of the sum of squares of two arguments.

### Returns

Returns the length of the hypotenuse  $\sqrt{x^2 + y^2}$ . If the correct value would overflow, returns  $+\infty$ . If the correct value would underflow, returns 0.

### Description

Calculate the length of the hypotenuse of a right triangle whose two sides have lengths  $x$  and  $y$  without undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.



## `__device__ int ilogb (double x)`

Compute the unbiased integer exponent of the argument.

### Returns

- ▶ If successful, returns the unbiased exponent of the argument.
- ▶ `ilogb(0)` returns `INT_MIN`.
- ▶ `ilogb(NaN)` returns `NaN`.
- ▶ `ilogb(x)` returns `INT_MAX` if  $x$  is  $\infty$  or the correct value is greater than `INT_MAX`.
- ▶ `ilogb(x)` return `INT_MIN` if the correct value is less than `INT_MIN`.

### Description

Calculates the unbiased integer exponent of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ __RETURN_TYPE isfinite (double a)`

Determine whether argument is finite.

### Returns

- ▶ With Visual Studio 2013 host compiler: `__RETURN_TYPE` is 'bool'. Returns true if and only if  $a$  is a finite value.
- ▶ With other host compilers: `__RETURN_TYPE` is 'int'. Returns a nonzero value if and only if  $a$  is a finite value.

### Description

Determine whether the floating-point value  $a$  is a finite value (zero, subnormal, or normal and not infinity or NaN).

## `__device__ __RETURN_TYPE isinf (double a)`

Determine whether argument is infinite.

### Returns

- ▶ With Visual Studio 2013 host compiler: Returns true if and only if  $a$  is a infinite value.
- ▶ With other host compilers: Returns a nonzero value if and only if  $a$  is a infinite value.

**Description**

Determine whether the floating-point value *a* is an infinite value (positive or negative).

**\_\_device\_\_ \_\_RETURN\_TYPE isnan (double a)**

Determine whether argument is a NaN.

**Returns**

- ▶ With Visual Studio 2013 host compiler: \_\_RETURN\_TYPE is 'bool'. Returns true if and only if *a* is a NaN value.
- ▶ With other host compilers: \_\_RETURN\_TYPE is 'int'. Returns a nonzero value if and only if *a* is a NaN value.

**Description**

Determine whether the floating-point value *a* is a NaN.

**\_\_device\_\_ \_\_CUDA\_MATH\_CRTIMP double j0 (double x)**

Calculate the value of the Bessel function of the first kind of order 0 for the input argument.

**Returns**

Returns the value of the Bessel function of the first kind of order 0.

- ▶  $j_0(\pm\infty)$  returns +0.
- ▶  $j_0(\text{NaN})$  returns NaN.

**Description**

Calculate the value of the Bessel function of the first kind of order 0 for the input argument  $x$ ,  $J_0(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ \_\_CUDA\_MATH\_CRTIMP double j1 (double x)**

Calculate the value of the Bessel function of the first kind of order 1 for the input argument.

**Returns**

Returns the value of the Bessel function of the first kind of order 1.

- ▶  $j_1(\pm 0)$  returns  $\pm 0$ .
- ▶  $j_1(\pm \infty)$  returns  $+0$ .
- ▶  $j_1(\text{NaN})$  returns NaN.

### Description

Calculate the value of the Bessel function of the first kind of order 1 for the input argument  $x$ ,  $J_1(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ __CUDA_MATH_CRTIMP double jn (int n, double x)`

Calculate the value of the Bessel function of the first kind of order  $n$  for the input argument.

### Returns

Returns the value of the Bessel function of the first kind of order  $n$ .

- ▶  $jn(n, \text{NaN})$  returns NaN.
- ▶  $jn(n, x)$  returns NaN for  $n < 0$ .
- ▶  $jn(n, +\infty)$  returns  $+0$ .

### Description

Calculate the value of the Bessel function of the first kind of order  $n$  for the input argument  $x$ ,  $J_n(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ __CUDA_MATH_CRTIMP double ldexp (double x, int exp)`

Calculate the value of  $x \cdot 2^{\text{exp}}$ .

### Returns

- ▶  $\text{ldexp}(x)$  returns  $\pm \infty$  if the correctly calculated value is outside the double floating point range.

**Description**

Calculate the value of  $x \cdot 2^{\text{exp}}$  of the input arguments  $x$  and  $\text{exp}$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ double lgamma (double x)**

Calculate the natural logarithm of the absolute value of the gamma function of the input argument.

**Returns**

- ▶ `lgamma(1)` returns +0.
- ▶ `lgamma(2)` returns +0.
- ▶ `lgamma(x)` returns  $\pm \infty$  if the correctly calculated value is outside the double floating point range.
- ▶ `lgamma(x)` returns  $+\infty$  if  $x \leq 0$  and  $x$  is an integer.
- ▶ `lgamma( $-\infty$ )` returns  $-\infty$ .
- ▶ `lgamma( $+\infty$ )` returns  $+\infty$ .

**Description**

Calculate the natural logarithm of the absolute value of the gamma function of the input argument  $x$ , namely the value of  $\log_e \left| \int_0^\infty e^{-t} t^{x-1} dt \right|$



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ long long int llrint (double x)**

Round input to nearest integer value.

**Returns**

Returns rounded integer value.

**Description**

Round  $x$  to the nearest integer value, with halfway cases rounded to the nearest even integer value. If the result is outside the range of the return type, the result is undefined.

## `__device__ long long int llround (double x)`

Round to nearest integer value.

### Returns

Returns rounded integer value.

### Description

Round  $x$  to the nearest integer value, with halfway cases rounded away from zero. If the result is outside the range of the return type, the result is undefined.



This function may be slower than alternate rounding methods. See [llrint\(\)](#).

## `__device__ double log (double x)`

Calculate the base  $e$  logarithm of the input argument.

### Returns

- ▶  $\log(\pm 0)$  returns  $-\infty$ .
- ▶  $\log(1)$  returns  $+0$ .
- ▶  $\log(x)$  returns NaN for  $x < 0$ .
- ▶  $\log(+\infty)$  returns  $+\infty$ .

### Description

Calculate the base  $e$  logarithm of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double log10 (double x)`

Calculate the base 10 logarithm of the input argument.

### Returns

- ▶  $\log_{10}(\pm 0)$  returns  $-\infty$ .
- ▶  $\log_{10}(1)$  returns  $+0$ .
- ▶  $\log_{10}(x)$  returns NaN for  $x < 0$ .
- ▶  $\log_{10}(+\infty)$  returns  $+\infty$ .

**Description**

Calculate the base 10 logarithm of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ double log1p (double x)**

Calculate the value of  $\log_e(1+x)$ .

**Returns**

- ▶  $\log1p(\pm 0)$  returns  $-\infty$ .
- ▶  $\log1p(-1)$  returns  $+0$ .
- ▶  $\log1p(x)$  returns NaN for  $x < -1$ .
- ▶  $\log1p(+\infty)$  returns  $+\infty$ .

**Description**

Calculate the value of  $\log_e(1+x)$  of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ double log2 (double x)**

Calculate the base 2 logarithm of the input argument.

**Returns**

- ▶  $\log2(\pm 0)$  returns  $-\infty$ .
- ▶  $\log2(1)$  returns  $+0$ .
- ▶  $\log2(x)$  returns NaN for  $x < 0$ .
- ▶  $\log2(+\infty)$  returns  $+\infty$ .

**Description**

Calculate the base 2 logarithm of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double logb (double x)`

Calculate the floating point representation of the exponent of the input argument.

### Returns

- ▶ `logb ± 0` returns  $-\infty$
- ▶ `logb ± ∞` returns  $+\infty$

### Description

Calculate the floating point representation of the exponent of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ long int lrint (double x)`

Round input to nearest integer value.

### Returns

Returns rounded integer value.

### Description

Round  $x$  to the nearest integer value, with halfway cases rounded to the nearest even integer value. If the result is outside the range of the return type, the result is undefined.

## `__device__ long int lround (double x)`

Round to nearest integer value.

### Returns

Returns rounded integer value.

### Description

Round  $x$  to the nearest integer value, with halfway cases rounded away from zero. If the result is outside the range of the return type, the result is undefined.



This function may be slower than alternate rounding methods. See [lrint\(\)](#).

## `__device__ __CUDA_MATH_CRTIMP double modf (double x, double *iptr)`

Break down the input argument into fractional and integral parts.

### Returns

- ▶ `modf(  $\pm x$ , iptr )` returns a result with the same sign as  $x$ .
- ▶ `modf(  $\pm \infty$ , iptr )` returns  $\pm 0$  and stores  $\pm \infty$  in the object pointed to by `iptr`.
- ▶ `modf(NaN, iptr )` stores a NaN in the object pointed to by `iptr` and returns a NaN.

### Description

Break down the argument  $x$  into fractional and integral parts. The integral part is stored in the argument `iptr`. Fractional and integral parts are given the same sign as the argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double nan (const char *tagp)`

Returns "Not a Number" value.

### Returns

- ▶ `nan(tagp )` returns NaN.

### Description

Return a representation of a quiet NaN. Argument `tagp` selects one of the possible representations.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double nearbyint (double x)`

Round the input argument to the nearest integer.

### Returns

- ▶ `nearbyint(  $\pm 0$  )` returns  $\pm 0$ .
- ▶ `nearbyint(  $\pm \infty$  )` returns  $\pm \infty$ .



**Description**

Round argument  $x$  to an integer value in double precision floating-point format.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ double nextafter (double x, double y)**

Return next representable double-precision floating-point value after argument.

**Returns**

- `nextafter(  $\pm \infty$ , y )` returns  $\pm \infty$ .

**Description**

Calculate the next representable double-precision floating-point value following  $x$  in the direction of  $y$ . For example, if  $y$  is greater than  $x$ , `nextafter()` returns the smallest representable number greater than  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ double norm (int dim, const double \*t)**

Calculate the square root of the sum of squares of any number of coordinates.

**Returns**

Returns the length of the dim-D vector  $\sqrt{p.1^2 + p.2^2 + \dots + p.\text{dim}^2}$ . If the correct value would overflow, returns  $+\infty$ . If the correct value would underflow, returns 0. If two of the input arguments is 0, returns remaining argument.

**Description**

Calculate the length of a vector  $p$ , dimension of which is passed as an argument without undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ __CUDA_MATH_CRTIMP double norm3d` (double a, double b, double c)

Calculate the square root of the sum of squares of three coordinates of the argument.

### Returns

Returns the length of 3D vector  $\sqrt{p.x^2 + p.y^2 + p.z^2}$ . If the correct value would overflow, returns  $+\infty$ . If the correct value would underflow, returns 0.

### Description

Calculate the length of three dimensional vector  $p$  in euclidean space without undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ __CUDA_MATH_CRTIMP double norm4d` (double a, double b, double c, double d)

Calculate the square root of the sum of squares of four coordinates of the argument.

### Returns

Returns the length of 4D vector  $\sqrt{p.x^2 + p.y^2 + p.z^2 + p.t^2}$ . If the correct value would overflow, returns  $+\infty$ . If the correct value would underflow, returns 0.

### Description

Calculate the length of four dimensional vector  $p$  in euclidean space without undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double normcdf` (double y)

Calculate the standard normal cumulative distribution function.

### Returns

- `normcdf(  $+\infty$  )` returns 1

- ▶ `normcdf( -  $\infty$  )` returns +0

### Description

Calculate the cumulative distribution function of the standard normal distribution for input argument  $y$ ,  $\Phi(y)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double normcdfinv (double y)`

Calculate the inverse of the standard normal cumulative distribution function.

### Returns

- ▶ `normcdfinv(0)` returns  $-\infty$ .
- ▶ `normcdfinv(1)` returns  $+\infty$ .
- ▶ `normcdfinv(x)` returns NaN if  $x$  is not in the interval  $[0,1]$ .

### Description

Calculate the inverse of the standard normal cumulative distribution function for input argument  $y$ ,  $\Phi^{-1}(y)$ . The function is defined for input values in the interval  $(0, 1)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double pow (double x, double y)`

Calculate the value of first argument to the power of second argument.

### Returns

- ▶ `pow(  $\pm 0$ ,  $y$  )` returns  $\pm \infty$  for  $y$  an integer less than 0.
- ▶ `pow(  $\pm 0$ ,  $y$  )` returns  $\pm 0$  for  $y$  an odd integer greater than 0.
- ▶ `pow(  $\pm 0$ ,  $y$  )` returns +0 for  $y > 0$  and not an odd integer.
- ▶ `pow(-1,  $\pm \infty$  )` returns 1.
- ▶ `pow(+1,  $y$  )` returns 1 for any  $y$ , even a NaN.
- ▶ `pow(x,  $\pm 0$  )` returns 1 for any  $x$ , even a NaN.
- ▶ `pow(x,  $y$  )` returns a NaN for finite  $x < 0$  and finite non-integer  $y$ .
- ▶ `pow(x,  $-\infty$  )` returns  $+\infty$  for  $|x| < 1$ .
- ▶ `pow(x,  $-\infty$  )` returns +0 for  $|x| > 1$ .

- ▶  $\text{pow}(x, +\infty)$  returns  $+0$  for  $|x| < 1$ .
- ▶  $\text{pow}(x, +\infty)$  returns  $+\infty$  for  $|x| > 1$ .
- ▶  $\text{pow}(-\infty, y)$  returns  $-0$  for  $y$  an odd integer less than  $0$ .
- ▶  $\text{pow}(-\infty, y)$  returns  $+0$  for  $y < 0$  and not an odd integer.
- ▶  $\text{pow}(-\infty, y)$  returns  $-\infty$  for  $y$  an odd integer greater than  $0$ .
- ▶  $\text{pow}(-\infty, y)$  returns  $+\infty$  for  $y > 0$  and not an odd integer.
- ▶  $\text{pow}(+\infty, y)$  returns  $+0$  for  $y < 0$ .
- ▶  $\text{pow}(+\infty, y)$  returns  $+\infty$  for  $y > 0$ .

### Description

Calculate the value of  $x$  to the power of  $y$



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double rcbrt (double x)`

Calculate reciprocal cube root function.

### Returns

- ▶  $\text{rcbrt}(\pm 0)$  returns  $\pm \infty$ .
- ▶  $\text{rcbrt}(\pm \infty)$  returns  $\pm 0$ .

### Description

Calculate reciprocal cube root function of  $x$



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double remainder (double x, double y)`

Compute double-precision floating-point remainder.

### Returns

- ▶  $\text{remainder}(x, 0)$  returns NaN.
- ▶  $\text{remainder}(\pm \infty, y)$  returns NaN.
- ▶  $\text{remainder}(x, \pm \infty)$  returns  $x$  for finite  $x$ .

**Description**

Compute double-precision floating-point remainder  $r$  of dividing  $x$  by  $y$  for nonzero  $y$ . Thus  $r = x - ny$ . The value  $n$  is the integer value nearest  $\frac{x}{y}$ . In the case when  $|n - \frac{x}{y}| = \frac{1}{2}$ , the even  $n$  value is chosen.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## **\_\_device\_\_ double remquo (double x, double y, int \*quo)**

Compute double-precision floating-point remainder and part of quotient.

**Returns**

Returns the remainder.

- ▶ `remquo(x, 0, quo)` returns NaN.
- ▶ `remquo(±∞, y, quo)` returns NaN.
- ▶ `remquo(x, ±∞, quo)` returns  $x$ .

**Description**

Compute a double-precision floating-point remainder in the same way as the `remainder()` function. Argument `quo` returns part of quotient upon division of  $x$  by  $y$ . Value `quo` has the same sign as  $\frac{x}{y}$  and may not be the exact quotient but agrees with the exact quotient in the low order 3 bits.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## **\_\_device\_\_ double rhypot (double x, double y)**

Calculate one over the square root of the sum of squares of two arguments.

**Returns**

Returns one over the length of the hypotenuse  $\frac{1}{\sqrt{x^2 + y^2}}$ . If the square root would overflow, returns 0. If the square root would underflow, returns  $+\infty$ .

**Description**

Calculate one over the length of the hypotenuse of a right triangle whose two sides have lengths  $x$  and  $y$  without undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ double rint (double x)**

Round to nearest integer value in floating-point.

**Returns**

Returns rounded integer value.

**Description**

Round  $x$  to the nearest integer value in floating-point format, with halfway cases rounded to the nearest even integer value.

**\_\_device\_\_ double rnorm (int dim, const double \*t)**

Calculate the reciprocal of square root of the sum of squares of any number of coordinates.

**Returns**

Returns one over the length of the vector  $\frac{1}{\sqrt{p.1^2 + p.2^2 + \dots + p.\text{dim}^2}}$ . If the square root would overflow, returns 0. If the square root would underflow, returns  $+\infty$ .

**Description**

Calculates one over the length of vector  $p$ , dimension of which is passed as an argument, in euclidean space without undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double rnorm3d (double a, double b, double c)`

Calculate one over the square root of the sum of squares of three coordinates of the argument.

### Returns

Returns one over the length of the 3D vector  $\frac{1}{\sqrt{p.x^2 + p.y^2 + p.z^2}}$ . If the square root would overflow, returns 0. If the square root would underflow, returns  $+\infty$ .

### Description

Calculate one over the length of three dimensional vector  $p$  in euclidean space undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double rnorm4d (double a, double b, double c, double d)`

Calculate one over the square root of the sum of squares of four coordinates of the argument.

### Returns

Returns one over the length of the 4D vector  $\frac{1}{\sqrt{p.x^2 + p.y^2 + p.z^2 + p.t^2}}$ . If the square root would overflow, returns 0. If the square root would underflow, returns  $+\infty$ .

### Description

Calculate one over the length of four dimensional vector  $p$  in euclidean space undue overflow or underflow.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double round (double x)`

Round to nearest integer value in floating-point.

### Returns

Returns rounded integer value.

### Description

Round  $x$  to the nearest integer value in floating-point format, with halfway cases rounded away from zero.



This function may be slower than alternate rounding methods. See [rint\(\)](#).

## `__device__ double rsqrt (double x)`

Calculate the reciprocal of the square root of the input argument.

### Returns

Returns  $1/\sqrt{x}$ .

- ▶ `rsqrt( +∞ )` returns `+0`.
- ▶ `rsqrt( ±0 )` returns  $\pm\infty$ .
- ▶ `rsqrt(x)` returns NaN if  $x$  is less than 0.

### Description

Calculate the reciprocal of the nonnegative square root of  $x$ ,  $1/\sqrt{x}$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double scalbln (double x, long int n)`

Scale floating-point input by integer power of two.

### Returns

Returns  $x * 2^n$ .

- ▶ `scalbln( ±0, n )` returns  $\pm 0$ .
- ▶ `scalbln(x, 0)` returns  $x$ .



- ▶ `scalbn(  $\pm \infty$ , n)` returns  $\pm \infty$ .

### Description

Scale  $x$  by  $2^n$  by efficient manipulation of the floating-point exponent.

## `__device__ double scalbn (double x, int n)`

Scale floating-point input by integer power of two.

### Returns

Returns  $x * 2^n$ .

- ▶ `scalbn(  $\pm 0$ , n)` returns  $\pm 0$ .
- ▶ `scalbn(x, 0)` returns  $x$ .
- ▶ `scalbn(  $\pm \infty$ , n)` returns  $\pm \infty$ .

### Description

Scale  $x$  by  $2^n$  by efficient manipulation of the floating-point exponent.

## `__device__ __RETURN_TYPE signbit (double a)`

Return the sign bit of the input.

### Returns

Reports the sign bit of all values including infinities, zeros, and NaNs.

- ▶ With Visual Studio 2013 host compiler: `__RETURN_TYPE` is 'bool'. Returns true if and only if  $a$  is negative.
- ▶ With other host compilers: `__RETURN_TYPE` is 'int'. Returns a nonzero value if and only if  $a$  is negative.

### Description

Determine whether the floating-point value  $a$  is negative.

## `__device__ double sin (double x)`

Calculate the sine of the input argument.

### Returns

- ▶ `sin(  $\pm 0$  )` returns  $\pm 0$ .
- ▶ `sin(  $\pm \infty$  )` returns NaN.

**Description**

Calculate the sine of the input argument  $x$  (measured in radians).



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ void sincos (double x, double \*sptr, double \*cptr)**

Calculate the sine and cosine of the first input argument.

**Returns**

- none

**Description**

Calculate the sine and cosine of the first input argument  $x$  (measured in radians). The results for sine and cosine are written into the second argument, `sptr`, and, respectively, third argument, `cptr`.

**See also:**

`sin()` and `cos()`.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

**\_\_device\_\_ void sincospi (double x, double \*sptr, double \*cptr)**

Calculate the sine and cosine of the first input argument  $x \times \pi$ .

**Returns**

- none

**Description**

Calculate the sine and cosine of the first input argument,  $x$  (measured in radians),  $x \times \pi$ . The results for sine and cosine are written into the second argument, `sptr`, and, respectively, third argument, `cptr`.

**See also:**

`sinpi()` and `cospi()`.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double sinh (double x)`

Calculate the hyperbolic sine of the input argument.

### Returns

- ▶ `sinh(  $\pm 0$  )` returns  $\pm 0$ .

### Description

Calculate the hyperbolic sine of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double sinpi (double x)`

Calculate the sine of the input argument  $\times \pi$ .

### Returns

- ▶ `sinpi(  $\pm 0$  )` returns  $\pm 0$ .
- ▶ `sinpi(  $\pm \infty$  )` returns NaN.

### Description

Calculate the sine of  $x \times \pi$  (measured in radians), where  $x$  is the input argument.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double sqrt (double x)`

Calculate the square root of the input argument.

### Returns

Returns  $\sqrt{x}$ .

- ▶  $\text{sqrt}(\pm 0)$  returns  $\pm 0$ .
- ▶  $\text{sqrt}(+\infty)$  returns  $+\infty$ .
- ▶  $\text{sqrt}(x)$  returns NaN if  $x$  is less than 0.

### Description

Calculate the nonnegative square root of  $x$ ,  $\sqrt{x}$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double tan (double x)`

Calculate the tangent of the input argument.

### Returns

- ▶  $\tan(\pm 0)$  returns  $\pm 0$ .
- ▶  $\tan(\pm \infty)$  returns NaN.

### Description

Calculate the tangent of the input argument  $x$  (measured in radians).



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double tanh (double x)`

Calculate the hyperbolic tangent of the input argument.

### Returns

- ▶  $\tanh(\pm 0)$  returns  $\pm 0$ .

### Description

Calculate the hyperbolic tangent of the input argument  $x$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## \_\_device\_\_ double tgamma (double x)

Calculate the gamma function of the input argument.

### Returns

- ▶ `tgamma( ± 0 )` returns  $\pm \infty$ .
- ▶ `tgamma(2)` returns +1.
- ▶ `tgamma(x)` returns  $\pm \infty$  if the correctly calculated value is outside the double floating point range.
- ▶ `tgamma(x)` returns NaN if  $x < 0$  and  $x$  is an integer.
- ▶ `tgamma( -  $\infty$  )` returns NaN.
- ▶ `tgamma( +  $\infty$  )` returns  $+\infty$ .

### Description

Calculate the gamma function of the input argument  $x$ , namely the value of  $\int_0^\infty e^{-t} t^{x-1} dt$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## \_\_device\_\_ double trunc (double x)

Truncate input argument to the integral part.

### Returns

Returns truncated integer value.

### Description

Round  $x$  to the nearest integer value that does not exceed  $x$  in magnitude.

## \_\_device\_\_ \_\_CUDA\_MATH\_CRTIMP double y0 (double x)

Calculate the value of the Bessel function of the second kind of order 0 for the input argument.

### Returns

Returns the value of the Bessel function of the second kind of order 0.

- ▶ `y0(0)` returns  $-\infty$ .
- ▶ `y0(x)` returns NaN for  $x < 0$ .
- ▶ `y0( +  $\infty$  )` returns +0.

- ▶  $y_0(\text{NaN})$  returns NaN.

### Description

Calculate the value of the Bessel function of the second kind of order 0 for the input argument  $x$ ,  $Y_0(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ __CUDA_MATH_CRTIMP double y1 (double x)`

Calculate the value of the Bessel function of the second kind of order 1 for the input argument.

### Returns

Returns the value of the Bessel function of the second kind of order 1.

- ▶  $y_1(0)$  returns  $-\infty$ .
- ▶  $y_1(x)$  returns NaN for  $x < 0$ .
- ▶  $y_1(+\infty)$  returns +0.
- ▶  $y_1(\text{NaN})$  returns NaN.

### Description

Calculate the value of the Bessel function of the second kind of order 1 for the input argument  $x$ ,  $Y_1(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ __CUDA_MATH_CRTIMP double yn (int n, double x)`

Calculate the value of the Bessel function of the second kind of order  $n$  for the input argument.

### Returns

Returns the value of the Bessel function of the second kind of order  $n$ .

- ▶  $yn(n, x)$  returns NaN for  $n < 0$ .
- ▶  $yn(n, 0)$  returns  $-\infty$ .
- ▶  $yn(n, x)$  returns NaN for  $x < 0$ .

- ▶  $yn(n, +\infty)$  returns +0.
- ▶  $yn(n, NaN)$  returns NaN.

### Description

Calculate the value of the Bessel function of the second kind of order  $n$  for the input argument  $x$ ,  $Y_n(x)$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## 1.5. Single Precision Intrinsics

This section describes single precision intrinsic functions that are only supported in device code. To use these functions you do not need to include any additional header files in your program.

### `__device__ float __cosf (float x)`

Calculate the fast approximate cosine of the input argument.

#### Returns

Returns the approximate cosine of  $x$ .

#### Description

Calculate the fast approximate cosine of the input argument  $x$ , measured in radians.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.2, Table 9.
- ▶ Input and output in the denormal range is flushed to sign preserving 0.0.

### `__device__ float __exp10f (float x)`

Calculate the fast approximate base 10 exponential of the input argument.

#### Returns

Returns an approximation to  $10^x$ .

## Description

Calculate the fast approximate base 10 exponential of the input argument  $x$ ,  $10^x$ .



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.2, Table 9.
- ▶ Most input and output values around denormal range are flushed to sign preserving 0.0.

## `__device__ float __expf (float x)`

Calculate the fast approximate base  $e$  exponential of the input argument.

## Returns

Returns an approximation to  $e^x$ .

## Description

Calculate the fast approximate base  $e$  exponential of the input argument  $x$ ,  $e^x$ .



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.2, Table 9.
- ▶ Most input and output values around denormal range are flushed to sign preserving 0.0.

## `__device__ float __fadd_rd (float x, float y)`

Add two floating point values in round-down mode.

## Returns

Returns  $x + y$ .

## Description

Compute the sum of  $x$  and  $y$  in round-down (to negative infinity) mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- ▶ This operation will never be merged into a single multiply-add instruction.



**\_\_device\_\_ float \_\_fadd\_rn (float x, float y)**

Add two floating point values in round-to-nearest-even mode.

**Returns**

Returns  $x + y$ .

**Description**

Compute the sum of  $x$  and  $y$  in round-to-nearest-even rounding mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- This operation will never be merged into a single multiply-add instruction.

**\_\_device\_\_ float \_\_fadd\_ru (float x, float y)**

Add two floating point values in round-up mode.

**Returns**

Returns  $x + y$ .

**Description**

Compute the sum of  $x$  and  $y$  in round-up (to positive infinity) mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- This operation will never be merged into a single multiply-add instruction.

**\_\_device\_\_ float \_\_fadd\_rz (float x, float y)**

Add two floating point values in round-towards-zero mode.

**Returns**

Returns  $x + y$ .

**Description**

Compute the sum of  $x$  and  $y$  in round-towards-zero mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- This operation will never be merged into a single multiply-add instruction.

## `__device__ float __fdiv_rd (float x, float y)`

Divide two floating point values in round-down mode.

### Returns

Returns  $x / y$ .

### Description

Divide two floating point values  $x$  by  $y$  in round-down (to negative infinity) mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float __fdiv_rn (float x, float y)`

Divide two floating point values in round-to-nearest-even mode.

### Returns

Returns  $x / y$ .

### Description

Divide two floating point values  $x$  by  $y$  in round-to-nearest-even mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float __fdiv_ru (float x, float y)`

Divide two floating point values in round-up mode.

### Returns

Returns  $x / y$ .

**Description**

Divide two floating point values  $x$  by  $y$  in round-up (to positive infinity) mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## **\_\_device\_\_ float \_\_fdiv\_rz (float x, float y)**

Divide two floating point values in round-towards-zero mode.

**Returns**

Returns  $x / y$ .

**Description**

Divide two floating point values  $x$  by  $y$  in round-towards-zero mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## **\_\_device\_\_ float \_\_fdividef (float x, float y)**

Calculate the fast approximate division of the input arguments.

**Returns**

Returns  $x / y$ .

- ▶ `__fdividef(  $\infty$ , y )` returns NaN for  $2^{126} < y < 2^{128}$ .
- ▶ `__fdividef(x, y)` returns 0 for  $2^{126} < y < 2^{128}$  and  $x \neq \infty$ .

**Description**

Calculate the fast approximate division of  $x$  by  $y$ .



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.2, Table 9.

## `__device__ float __fmaf_rd (float x, float y, float z)`

Compute  $x \times y + z$  as a single operation, in round-down mode.

### Returns

Returns the rounded value of  $x \times y + z$  as a single operation.

- ▶ `fmaf(  $\pm \infty$ ,  $\pm 0$ , z )` returns NaN.
- ▶ `fmaf(  $\pm 0$ ,  $\pm \infty$ , z )` returns NaN.
- ▶ `fmaf(x, y,  $-\infty$ )` returns NaN if  $x \times y$  is an exact  $+\infty$ .
- ▶ `fmaf(x, y,  $+\infty$ )` returns NaN if  $x \times y$  is an exact  $-\infty$ .

### Description

Computes the value of  $x \times y + z$  as a single ternary operation, rounding the result once in round-down (to negative infinity) mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float __fmaf_rn (float x, float y, float z)`

Compute  $x \times y + z$  as a single operation, in round-to-nearest-even mode.

### Returns

Returns the rounded value of  $x \times y + z$  as a single operation.

- ▶ `fmaf(  $\pm \infty$ ,  $\pm 0$ , z )` returns NaN.
- ▶ `fmaf(  $\pm 0$ ,  $\pm \infty$ , z )` returns NaN.
- ▶ `fmaf(x, y,  $-\infty$ )` returns NaN if  $x \times y$  is an exact  $+\infty$ .
- ▶ `fmaf(x, y,  $+\infty$ )` returns NaN if  $x \times y$  is an exact  $-\infty$ .

### Description

Computes the value of  $x \times y + z$  as a single ternary operation, rounding the result once in round-to-nearest-even mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float __fmaf_ru (float x, float y, float z)`

Compute  $x \times y + z$  as a single operation, in round-up mode.

### Returns

Returns the rounded value of  $x \times y + z$  as a single operation.

- ▶ `fmaf(  $\pm \infty$ ,  $\pm 0$ , z )` returns NaN.
- ▶ `fmaf(  $\pm 0$ ,  $\pm \infty$ , z )` returns NaN.
- ▶ `fmaf(x, y,  $-\infty$ )` returns NaN if  $x \times y$  is an exact  $+\infty$ .
- ▶ `fmaf(x, y,  $+\infty$ )` returns NaN if  $x \times y$  is an exact  $-\infty$ .

### Description

Computes the value of  $x \times y + z$  as a single ternary operation, rounding the result once in round-up (to positive infinity) mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float __fmaf_rz (float x, float y, float z)`

Compute  $x \times y + z$  as a single operation, in round-towards-zero mode.

### Returns

Returns the rounded value of  $x \times y + z$  as a single operation.

- ▶ `fmaf(  $\pm \infty$ ,  $\pm 0$ , z )` returns NaN.
- ▶ `fmaf(  $\pm 0$ ,  $\pm \infty$ , z )` returns NaN.
- ▶ `fmaf(x, y,  $-\infty$ )` returns NaN if  $x \times y$  is an exact  $+\infty$ .
- ▶ `fmaf(x, y,  $+\infty$ )` returns NaN if  $x \times y$  is an exact  $-\infty$ .

### Description

Computes the value of  $x \times y + z$  as a single ternary operation, rounding the result once in round-towards-zero mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float __fmul_rd (float x, float y)`

Multiply two floating point values in round-down mode.

### Returns

Returns  $x * y$ .

### Description

Compute the product of  $x$  and  $y$  in round-down (to negative infinity) mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- ▶ This operation will never be merged into a single multiply-add instruction.

## `__device__ float __fmul_rn (float x, float y)`

Multiply two floating point values in round-to-nearest-even mode.

### Returns

Returns  $x * y$ .

### Description

Compute the product of  $x$  and  $y$  in round-to-nearest-even mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- ▶ This operation will never be merged into a single multiply-add instruction.

## `__device__ float __fmul_ru (float x, float y)`

Multiply two floating point values in round-up mode.

### Returns

Returns  $x * y$ .

### Description

Compute the product of  $x$  and  $y$  in round-up (to positive infinity) mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- This operation will never be merged into a single multiply-add instruction.

## `__device__ float __fmul_rz (float x, float y)`

Multiply two floating point values in round-towards-zero mode.

### Returns

Returns  $x * y$ .

### Description

Compute the product of  $x$  and  $y$  in round-towards-zero mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- This operation will never be merged into a single multiply-add instruction.

## `__device__ float __frcp_rd (float x)`

Compute  $\frac{1}{x}$  in round-down mode.

### Returns

Returns  $\frac{1}{x}$ .

### Description

Compute the reciprocal of  $x$  in round-down (to negative infinity) mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float __frcp_rn (float x)`

Compute  $\frac{1}{x}$  in round-to-nearest-even mode.

### Returns

Returns  $\frac{1}{x}$ .

**Description**

Compute the reciprocal of  $x$  in round-to-nearest-even mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

**\_\_device\_\_ float \_\_frcp\_ru (float x)**

Compute  $\frac{1}{x}$  in round-up mode.

**Returns**

Returns  $\frac{1}{x}$ .

**Description**

Compute the reciprocal of  $x$  in round-up (to positive infinity) mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

**\_\_device\_\_ float \_\_frcp\_rz (float x)**

Compute  $\frac{1}{x}$  in round-towards-zero mode.

**Returns**

Returns  $\frac{1}{x}$ .

**Description**

Compute the reciprocal of  $x$  in round-towards-zero mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.



**\_\_device\_\_ float \_\_frsqrt\_rn (float x)**

Compute  $1/\sqrt{x}$  in round-to-nearest-even mode.

**Returns**

Returns  $1/\sqrt{x}$ .

**Description**

Compute the reciprocal square root of  $x$  in round-to-nearest-even mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

**\_\_device\_\_ float \_\_fsqrt\_rd (float x)**

Compute  $\sqrt{x}$  in round-down mode.

**Returns**

Returns  $\sqrt{x}$ .

**Description**

Compute the square root of  $x$  in round-down (to negative infinity) mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

**\_\_device\_\_ float \_\_fsqrt\_rn (float x)**

Compute  $\sqrt{x}$  in round-to-nearest-even mode.

**Returns**

Returns  $\sqrt{x}$ .

**Description**

Compute the square root of  $x$  in round-to-nearest-even mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float __fsqrt_ru (float x)`

Compute  $\sqrt{x}$  in round-up mode.

### Returns

Returns  $\sqrt{x}$ .

### Description

Compute the square root of  $x$  in round-up (to positive infinity) mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float __fsqrt_rz (float x)`

Compute  $\sqrt{x}$  in round-towards-zero mode.

### Returns

Returns  $\sqrt{x}$ .

### Description

Compute the square root of  $x$  in round-towards-zero mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.

## `__device__ float __fsub_rd (float x, float y)`

Subtract two floating point values in round-down mode.

### Returns

Returns  $x - y$ .

**Description**

Compute the difference of  $x$  and  $y$  in round-down (to negative infinity) mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- ▶ This operation will never be merged into a single multiply-add instruction.

## **\_\_device\_\_ float \_\_fsub\_rn (float x, float y)**

Subtract two floating point values in round-to-nearest-even mode.

**Returns**

Returns  $x - y$ .

**Description**

Compute the difference of  $x$  and  $y$  in round-to-nearest-even rounding mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- ▶ This operation will never be merged into a single multiply-add instruction.

## **\_\_device\_\_ float \_\_fsub\_ru (float x, float y)**

Subtract two floating point values in round-up mode.

**Returns**

Returns  $x - y$ .

**Description**

Compute the difference of  $x$  and  $y$  in round-up (to positive infinity) mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- ▶ This operation will never be merged into a single multiply-add instruction.

## `__device__ float __fsub_rz (float x, float y)`

Subtract two floating point values in round-towards-zero mode.

### Returns

Returns  $x - y$ .

### Description

Compute the difference of  $x$  and  $y$  in round-towards-zero mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 6.
- ▶ This operation will never be merged into a single multiply-add instruction.

## `__device__ float __log10f (float x)`

Calculate the fast approximate base 10 logarithm of the input argument.

### Returns

Returns an approximation to  $\log_{10}(x)$ .

### Description

Calculate the fast approximate base 10 logarithm of the input argument  $x$ .



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.2, Table 9.
- ▶ Most input and output values around denormal range are flushed to sign preserving 0.0.

## `__device__ float __log2f (float x)`

Calculate the fast approximate base 2 logarithm of the input argument.

### Returns

Returns an approximation to  $\log_2(x)$ .

### Description

Calculate the fast approximate base 2 logarithm of the input argument  $x$ .



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.2, Table 9.
- Input and output in the denormal range is flushed to sign preserving 0.0.

## `__device__ float __logf (float x)`

Calculate the fast approximate base  $e$  logarithm of the input argument.

### Returns

Returns an approximation to  $\log_e(x)$ .

### Description

Calculate the fast approximate base  $e$  logarithm of the input argument  $x$ .



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.2, Table 9.
- Most input and output values around denormal range are flushed to sign preserving 0.0.

## `__device__ float __powf (float x, float y)`

Calculate the fast approximate of  $x^y$ .

### Returns

Returns an approximation to  $x^y$ .

### Description

Calculate the fast approximate of  $x$ , the first input argument, raised to the power of  $y$ , the second input argument,  $x^y$ .



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.2, Table 9.
- Most input and output values around denormal range are flushed to sign preserving 0.0.

## `__device__ float __saturatef (float x)`

Clamp the input argument to  $[+0.0, 1.0]$ .

### Returns

- ▶ `__saturatef(x)` returns 0 if  $x < 0$ .
- ▶ `__saturatef(x)` returns 1 if  $x > 1$ .
- ▶ `__saturatef(x)` returns  $x$  if  $0 \leq x \leq 1$ .
- ▶ `__saturatef(NaN)` returns 0.

### Description

Clamp the input argument  $x$  to be within the interval  $[+0.0, 1.0]$ .

## `__device__ void __sincosf (float x, float *sptr, float *cptr)`

Calculate the fast approximate of sine and cosine of the first input argument.

### Returns

- ▶ none

### Description

Calculate the fast approximate of sine and cosine of the first input argument  $x$  (measured in radians). The results for sine and cosine are written into the second argument, `sptr`, and, respectively, third argument, `cptr`.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.2, Table 9.
- ▶ Denorm input/output is flushed to sign preserving 0.0.

## `__device__ float __sinf (float x)`

Calculate the fast approximate sine of the input argument.

### Returns

Returns the approximate sine of  $x$ .

### Description

Calculate the fast approximate sine of the input argument  $x$ , measured in radians.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.2, Table 9.
- Input and output in the denormal range is flushed to sign preserving 0.0.

## `__device__ float __tanf (float x)`

Calculate the fast approximate tangent of the input argument.

### Returns

Returns the approximate tangent of  $x$ .

### Description

Calculate the fast approximate tangent of the input argument  $x$ , measured in radians.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.2, Table 9.
- The result is computed as the fast divide of `__sinf()` by `__cosf()`. Denormal input and output are flushed to sign-preserving 0.0 at each step of the computation.

## 1.6. Double Precision Intrinsics

This section describes double precision intrinsic functions that are only supported in device code. To use these functions you do not need to include any additional header files in your program.

## `__device__ double __dadd_rd (double x, double y)`

Add two floating point values in round-down mode.

### Returns

Returns  $x + y$ .

### Description

Adds two floating point values  $x$  and  $y$  in round-down (to negative infinity) mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

- ▶ This operation will never be merged into a single multiply-add instruction.

## `__device__ double __dadd_rn (double x, double y)`

Add two floating point values in round-to-nearest-even mode.

### Returns

Returns  $x + y$ .

### Description

Adds two floating point values  $x$  and  $y$  in round-to-nearest-even mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- ▶ This operation will never be merged into a single multiply-add instruction.

## `__device__ double __dadd_ru (double x, double y)`

Add two floating point values in round-up mode.

### Returns

Returns  $x + y$ .

### Description

Adds two floating point values  $x$  and  $y$  in round-up (to positive infinity) mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- ▶ This operation will never be merged into a single multiply-add instruction.

## `__device__ double __dadd_rz (double x, double y)`

Add two floating point values in round-towards-zero mode.

### Returns

Returns  $x + y$ .

### Description

Adds two floating point values  $x$  and  $y$  in round-towards-zero mode.





- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- This operation will never be merged into a single multiply-add instruction.

## `__device__ double __ddiv_rd (double x, double y)`

Divide two floating point values in round-down mode.

### Returns

Returns  $x / y$ .

### Description

Divides two floating point values  $x$  by  $y$  in round-down (to negative infinity) mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- Requires compute capability  $\geq 2.0$ .

## `__device__ double __ddiv_rn (double x, double y)`

Divide two floating point values in round-to-nearest-even mode.

### Returns

Returns  $x / y$ .

### Description

Divides two floating point values  $x$  by  $y$  in round-to-nearest-even mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- Requires compute capability  $\geq 2.0$ .

## `__device__ double __ddiv_ru (double x, double y)`

Divide two floating point values in round-up mode.

### Returns

Returns  $x / y$ .

**Description**

Divides two floating point values  $x$  by  $y$  in round-up (to positive infinity) mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- ▶ Requires compute capability  $\geq 2.0$ .

**\_\_device\_\_ double \_\_ddiv\_rz (double x, double y)**

Divide two floating point values in round-towards-zero mode.

**Returns**

Returns  $x / y$ .

**Description**

Divides two floating point values  $x$  by  $y$  in round-towards-zero mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- ▶ Requires compute capability  $\geq 2.0$ .

**\_\_device\_\_ double \_\_dmul\_rd (double x, double y)**

Multiply two floating point values in round-down mode.

**Returns**

Returns  $x * y$ .

**Description**

Multiplies two floating point values  $x$  and  $y$  in round-down (to negative infinity) mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- ▶ This operation will never be merged into a single multiply-add instruction.

## `__device__ double __dmul_rn (double x, double y)`

Multiply two floating point values in round-to-nearest-even mode.

### Returns

Returns  $x * y$ .

### Description

Multiplies two floating point values  $x$  and  $y$  in round-to-nearest-even mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- ▶ This operation will never be merged into a single multiply-add instruction.

## `__device__ double __dmul_ru (double x, double y)`

Multiply two floating point values in round-up mode.

### Returns

Returns  $x * y$ .

### Description

Multiplies two floating point values  $x$  and  $y$  in round-up (to positive infinity) mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- ▶ This operation will never be merged into a single multiply-add instruction.

## `__device__ double __dmul_rz (double x, double y)`

Multiply two floating point values in round-towards-zero mode.

### Returns

Returns  $x * y$ .

### Description

Multiplies two floating point values  $x$  and  $y$  in round-towards-zero mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- This operation will never be merged into a single multiply-add instruction.

## `__device__ double __drcp_rd (double x)`

Compute  $\frac{1}{x}$  in round-down mode.

### Returns

Returns  $\frac{1}{x}$ .

### Description

Compute the reciprocal of  $x$  in round-down (to negative infinity) mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- Requires compute capability  $\geq 2.0$ .

## `__device__ double __drcp_rn (double x)`

Compute  $\frac{1}{x}$  in round-to-nearest-even mode.

### Returns

Returns  $\frac{1}{x}$ .

### Description

Compute the reciprocal of  $x$  in round-to-nearest-even mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- Requires compute capability  $\geq 2.0$ .

**\_\_device\_\_ double \_\_drcp\_ru (double x)**

Compute  $\frac{1}{x}$  in round-up mode.

**Returns**

Returns  $\frac{1}{x}$ .

**Description**

Compute the reciprocal of  $x$  in round-up (to positive infinity) mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- Requires compute capability  $\geq 2.0$ .

**\_\_device\_\_ double \_\_drcp\_rz (double x)**

Compute  $\frac{1}{x}$  in round-towards-zero mode.

**Returns**

Returns  $\frac{1}{x}$ .

**Description**

Compute the reciprocal of  $x$  in round-towards-zero mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- Requires compute capability  $\geq 2.0$ .

**\_\_device\_\_ double \_\_dsqrt\_rd (double x)**

Compute  $\sqrt{x}$  in round-down mode.

**Returns**

Returns  $\sqrt{x}$ .

**Description**

Compute the square root of  $x$  in round-down (to negative infinity) mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- ▶ Requires compute capability  $\geq 2.0$ .

## `__device__ double __dsqrt_rn (double x)`

Compute  $\sqrt{x}$  in round-to-nearest-even mode.

### Returns

Returns  $\sqrt{x}$ .

### Description

Compute the square root of  $x$  in round-to-nearest-even mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- ▶ Requires compute capability  $\geq 2.0$ .

## `__device__ double __dsqrt_ru (double x)`

Compute  $\sqrt{x}$  in round-up mode.

### Returns

Returns  $\sqrt{x}$ .

### Description

Compute the square root of  $x$  in round-up (to positive infinity) mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- ▶ Requires compute capability  $\geq 2.0$ .

## `__device__ double __dsqrt_rz (double x)`

Compute  $\sqrt{x}$  in round-towards-zero mode.

### Returns

Returns  $\sqrt{x}$ .

### Description

Compute the square root of  $x$  in round-towards-zero mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- Requires compute capability  $\geq 2.0$ .

## `__device__ double __dsub_rd (double x, double y)`

Subtract two floating point values in round-down mode.

### Returns

Returns  $x - y$ .

### Description

Subtracts two floating point values  $x$  and  $y$  in round-down (to negative infinity) mode.



- For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- This operation will never be merged into a single multiply-add instruction.

## `__device__ double __dsub_rn (double x, double y)`

Subtract two floating point values in round-to-nearest-even mode.

### Returns

Returns  $x - y$ .

### Description

Subtracts two floating point values  $x$  and  $y$  in round-to-nearest-even mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- ▶ This operation will never be merged into a single multiply-add instruction.

## `__device__ double __dsub_ru (double x, double y)`

Subtract two floating point values in round-up mode.

### Returns

Returns  $x - y$ .

### Description

Subtracts two floating point values  $x$  and  $y$  in round-up (to positive infinity) mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- ▶ This operation will never be merged into a single multiply-add instruction.

## `__device__ double __dsub_rz (double x, double y)`

Subtract two floating point values in round-towards-zero mode.

### Returns

Returns  $x - y$ .

### Description

Subtracts two floating point values  $x$  and  $y$  in round-towards-zero mode.



- ▶ For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.
- ▶ This operation will never be merged into a single multiply-add instruction.



## `__device__ double __fma_rd (double x, double y, double z)`

Compute  $x \times y + z$  as a single operation in round-down mode.

### Returns

Returns the rounded value of  $x \times y + z$  as a single operation.

- ▶ `fmaf(  $\pm \infty$ ,  $\pm 0$ , z )` returns NaN.
- ▶ `fmaf(  $\pm 0$ ,  $\pm \infty$ , z )` returns NaN.
- ▶ `fmaf(x, y,  $-\infty$ )` returns NaN if  $x \times y$  is an exact  $+\infty$
- ▶ `fmaf(x, y,  $+\infty$ )` returns NaN if  $x \times y$  is an exact  $-\infty$

### Description

Computes the value of  $x \times y + z$  as a single ternary operation, rounding the result once in round-down (to negative infinity) mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double __fma_rn (double x, double y, double z)`

Compute  $x \times y + z$  as a single operation in round-to-nearest-even mode.

### Returns

Returns the rounded value of  $x \times y + z$  as a single operation.

- ▶ `fmaf(  $\pm \infty$ ,  $\pm 0$ , z )` returns NaN.
- ▶ `fmaf(  $\pm 0$ ,  $\pm \infty$ , z )` returns NaN.
- ▶ `fmaf(x, y,  $-\infty$ )` returns NaN if  $x \times y$  is an exact  $+\infty$
- ▶ `fmaf(x, y,  $+\infty$ )` returns NaN if  $x \times y$  is an exact  $-\infty$

### Description

Computes the value of  $x \times y + z$  as a single ternary operation, rounding the result once in round-to-nearest-even mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double __fma_ru (double x, double y, double z)`

Compute  $x \times y + z$  as a single operation in round-up mode.

### Returns

Returns the rounded value of  $x \times y + z$  as a single operation.

- ▶ `fmaf(  $\pm \infty$ ,  $\pm 0$ , z )` returns NaN.
- ▶ `fmaf(  $\pm 0$ ,  $\pm \infty$ , z )` returns NaN.
- ▶ `fmaf(x, y,  $-\infty$ )` returns NaN if  $x \times y$  is an exact  $+\infty$
- ▶ `fmaf(x, y,  $+\infty$ )` returns NaN if  $x \times y$  is an exact  $-\infty$

### Description

Computes the value of  $x \times y + z$  as a single ternary operation, rounding the result once in round-up (to positive infinity) mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## `__device__ double __fma_rz (double x, double y, double z)`

Compute  $x \times y + z$  as a single operation in round-towards-zero mode.

### Returns

Returns the rounded value of  $x \times y + z$  as a single operation.

- ▶ `fmaf(  $\pm \infty$ ,  $\pm 0$ , z )` returns NaN.
- ▶ `fmaf(  $\pm 0$ ,  $\pm \infty$ , z )` returns NaN.
- ▶ `fmaf(x, y,  $-\infty$ )` returns NaN if  $x \times y$  is an exact  $+\infty$
- ▶ `fmaf(x, y,  $+\infty$ )` returns NaN if  $x \times y$  is an exact  $-\infty$

### Description

Computes the value of  $x \times y + z$  as a single ternary operation, rounding the result once in round-towards-zero mode.



For accuracy information for this function see the CUDA C Programming Guide, Appendix D.1, Table 7.

## 1.7. Integer Intrinsics

This section describes integer intrinsic functions that are only supported in device code. To use these functions you do not need to include any additional header files in your program.

**`__device__ unsigned int __brev (unsigned int x)`**

Reverse the bit order of a 32 bit unsigned integer.

### Returns

Returns the bit-reversed value of  $x$ . i.e. bit  $N$  of the return value corresponds to bit  $31-N$  of  $x$ .

### Description

Reverses the bit order of the 32 bit unsigned integer  $x$ .

**`__device__ unsigned long long int __brevll (unsigned long long int x)`**

Reverse the bit order of a 64 bit unsigned integer.

### Returns

Returns the bit-reversed value of  $x$ . i.e. bit  $N$  of the return value corresponds to bit  $63-N$  of  $x$ .

### Description

Reverses the bit order of the 64 bit unsigned integer  $x$ .

**`__device__ unsigned int __byte_perm (unsigned int x, unsigned int y, unsigned int s)`**

Return selected bytes from two 32 bit unsigned integers.

### Returns

The returned value  $r$  is computed to be:  $result[n] := input[selector[n]]$  where  $result[n]$  is the  $n$ th byte of  $r$ .

**Description**

`byte_perm(x,y,s)` returns a 32-bit integer consisting of four bytes from eight input bytes provided in the two input integers `x` and `y`, as specified by a selector, `s`.

The input bytes are indexed as follows: `input[0] = x<7:0>` `input[1] = x<15:8>` `input[2] = x<23:16>` `input[3] = x<31:24>` `input[4] = y<7:0>` `input[5] = y<15:8>` `input[6] = y<23:16>` `input[7] = y<31:24>` The selector indices are as follows (the upper 16-bits of the selector are not used): `selector[0] = s<2:0>` `selector[1] = s<6:4>` `selector[2] = s<10:8>` `selector[3] = s<14:12>`

**\_\_device\_\_ int \_\_clz (int x)**

Return the number of consecutive high-order zero bits in a 32 bit integer.

**Returns**

Returns a value between 0 and 32 inclusive representing the number of zero bits.

**Description**

Count the number of consecutive leading zero bits, starting at the most significant bit (bit 31) of `x`.

**\_\_device\_\_ int \_\_clzll (long long int x)**

Count the number of consecutive high-order zero bits in a 64 bit integer.

**Returns**

Returns a value between 0 and 64 inclusive representing the number of zero bits.

**Description**

Count the number of consecutive leading zero bits, starting at the most significant bit (bit 63) of `x`.

**\_\_device\_\_ int \_\_ffs (int x)**

Find the position of the least significant bit set to 1 in a 32 bit integer.

**Returns**

Returns a value between 0 and 32 inclusive representing the position of the first bit set.

- `__ffs(0)` returns 0.

**Description**

Find the position of the first (least significant) bit set to 1 in  $x$ , where the least significant bit position is 1.

**\_\_device\_\_ int \_\_ffsll (long long int x)**

Find the position of the least significant bit set to 1 in a 64 bit integer.

**Returns**

Returns a value between 0 and 64 inclusive representing the position of the first bit set.

- `__ffsll(0)` returns 0.

**Description**

Find the position of the first (least significant) bit set to 1 in  $x$ , where the least significant bit position is 1.

**\_\_device\_\_ unsigned int \_\_funnelshift\_l (unsigned int lo, unsigned int hi, unsigned int shift)**

Concatenate  $hi : lo$ , shift left by  $shift \& 31$  bits, return the most significant 32 bits.

**Returns**

Returns the most significant 32 bits of the shifted 64-bit value.

**Description**

Shift the 64-bit value formed by concatenating argument  $lo$  and  $hi$  left by the amount specified by the argument  $shift$ . Argument  $lo$  holds bits 31:0 and argument  $hi$  holds bits 63:32 of the 64-bit source value. The source is shifted left by the wrapped value of  $shift$  ( $shift \& 31$ ). The most significant 32-bits of the result are returned.

**\_\_device\_\_ unsigned int \_\_funnelshift\_lc (unsigned int lo, unsigned int hi, unsigned int shift)**

Concatenate  $hi : lo$ , shift left by  $\min(shift, 32)$  bits, return the most significant 32 bits.

**Returns**

Returns the most significant 32 bits of the shifted 64-bit value.

**Description**

Shift the 64-bit value formed by concatenating argument  $lo$  and  $hi$  left by the amount specified by the argument  $shift$ . Argument  $lo$  holds bits 31:0 and argument  $hi$  holds

bits 63:32 of the 64-bit source value. The source is shifted left by the clamped value of `shift` (`min(shift, 32)`). The most significant 32-bits of the result are returned.

## `__device__ unsigned int __funnelshift_r (unsigned int lo, unsigned int hi, unsigned int shift)`

Concatenate `hi : lo`, shift right by `shift` & 31 bits, return the least significant 32 bits.

### Returns

Returns the least significant 32 bits of the shifted 64-bit value.

### Description

Shift the 64-bit value formed by concatenating argument `lo` and `hi` right by the amount specified by the argument `shift`. Argument `lo` holds bits 31:0 and argument `hi` holds bits 63:32 of the 64-bit source value. The source is shifted right by the wrapped value of `shift` (`shift & 31`). The least significant 32-bits of the result are returned.

## `__device__ unsigned int __funnelshift_rc (unsigned int lo, unsigned int hi, unsigned int shift)`

Concatenate `hi : lo`, shift right by `min(shift, 32)` bits, return the least significant 32 bits.

### Returns

Returns the least significant 32 bits of the shifted 64-bit value.

### Description

Shift the 64-bit value formed by concatenating argument `lo` and `hi` right by the amount specified by the argument `shift`. Argument `lo` holds bits 31:0 and argument `hi` holds bits 63:32 of the 64-bit source value. The source is shifted right by the clamped value of `shift` (`min(shift, 32)`). The least significant 32-bits of the result are returned.

## `__device__ int __hadd (int, int)`

Compute average of signed input arguments, avoiding overflow in the intermediate sum.

### Returns

Returns a signed integer value representing the signed average value of the two inputs.

**Description**

Compute average of signed input arguments  $x$  and  $y$  as  $(x + y) \gg 1$ , avoiding overflow in the intermediate sum.

**\_\_device\_\_ int \_\_mul24 (int x, int y)**

Calculate the least significant 32 bits of the product of the least significant 24 bits of two integers.

**Returns**

Returns the least significant 32 bits of the product  $x * y$ .

**Description**

Calculate the least significant 32 bits of the product of the least significant 24 bits of  $x$  and  $y$ . The high order 8 bits of  $x$  and  $y$  are ignored.

**\_\_device\_\_ long long int \_\_mul64hi (long long int x, long long int y)**

Calculate the most significant 64 bits of the product of the two 64 bit integers.

**Returns**

Returns the most significant 64 bits of the product  $x * y$ .

**Description**

Calculate the most significant 64 bits of the 128-bit product  $x * y$ , where  $x$  and  $y$  are 64-bit integers.

**\_\_device\_\_ int \_\_mulhi (int x, int y)**

Calculate the most significant 32 bits of the product of the two 32 bit integers.

**Returns**

Returns the most significant 32 bits of the product  $x * y$ .

**Description**

Calculate the most significant 32 bits of the 64-bit product  $x * y$ , where  $x$  and  $y$  are 32-bit integers.

**\_\_device\_\_ int \_\_popc (unsigned int x)**

Count the number of bits that are set to 1 in a 32 bit integer.

**Returns**

Returns a value between 0 and 32 inclusive representing the number of set bits.

**Description**

Count the number of bits that are set to 1 in x.

**\_\_device\_\_ int \_\_popcll (unsigned long long int x)**

Count the number of bits that are set to 1 in a 64 bit integer.

**Returns**

Returns a value between 0 and 64 inclusive representing the number of set bits.

**Description**

Count the number of bits that are set to 1 in x.

**\_\_device\_\_ int \_\_rhadd (int, int)**

Compute rounded average of signed input arguments, avoiding overflow in the intermediate sum.

**Returns**

Returns a signed integer value representing the signed rounded average value of the two inputs.

**Description**

Compute average of signed input arguments x and y as  $(x + y + 1) \gg 1$ , avoiding overflow in the intermediate sum.

**\_\_device\_\_ unsigned int \_\_sad (int x, int y, unsigned int z)**

Calculate  $|x - y| + z$ , the sum of absolute difference.

**Returns**

Returns  $|x - y| + z$ .



**Description**

Calculate  $|x - y| + z$ , the 32-bit sum of the third argument  $z$  plus and the absolute value of the difference between the first argument,  $x$ , and second argument,  $y$ .

Inputs  $x$  and  $y$  are signed 32-bit integers, input  $z$  is a 32-bit unsigned integer.

## **\_\_device\_\_ unsigned int \_\_uhadd (unsigned int, unsigned int)**

Compute average of unsigned input arguments, avoiding overflow in the intermediate sum.

**Returns**

Returns an unsigned integer value representing the unsigned average value of the two inputs.

**Description**

Compute average of unsigned input arguments  $x$  and  $y$  as  $(x + y) \gg 1$ , avoiding overflow in the intermediate sum.

## **\_\_device\_\_ unsigned int \_\_umul24 (unsigned int x, unsigned int y)**

Calculate the least significant 32 bits of the product of the least significant 24 bits of two unsigned integers.

**Returns**

Returns the least significant 32 bits of the product  $x * y$ .

**Description**

Calculate the least significant 32 bits of the product of the least significant 24 bits of  $x$  and  $y$ . The high order 8 bits of  $x$  and  $y$  are ignored.

## **\_\_device\_\_ unsigned long long int \_\_umul64hi (unsigned long long int x, unsigned long long int y)**

Calculate the most significant 64 bits of the product of the two 64 unsigned bit integers.

**Returns**

Returns the most significant 64 bits of the product  $x * y$ .

**Description**

Calculate the most significant 64 bits of the 128-bit product  $x * y$ , where  $x$  and  $y$  are 64-bit unsigned integers.

**\_\_device\_\_ unsigned int \_\_umulhi (unsigned int x, unsigned int y)**

Calculate the most significant 32 bits of the product of the two 32 bit unsigned integers.

**Returns**

Returns the most significant 32 bits of the product  $x * y$ .

**Description**

Calculate the most significant 32 bits of the 64-bit product  $x * y$ , where  $x$  and  $y$  are 32-bit unsigned integers.

**\_\_device\_\_ unsigned int \_\_urhadd (unsigned int, unsigned int)**

Compute rounded average of unsigned input arguments, avoiding overflow in the intermediate sum.

**Returns**

Returns an unsigned integer value representing the unsigned rounded average value of the two inputs.

**Description**

Compute average of unsigned input arguments  $x$  and  $y$  as  $(x + y + 1) >> 1$ , avoiding overflow in the intermediate sum.

**\_\_device\_\_ unsigned int \_\_usad (unsigned int x, unsigned int y, unsigned int z)**

Calculate  $|x - y| + z$ , the sum of absolute difference.

**Returns**

Returns  $|x - y| + z$ .

**Description**

Calculate  $|x - y| + z$ , the 32-bit sum of the third argument  $z$  plus and the absolute value of the difference between the first argument,  $x$ , and second argument,  $y$ .

Inputs  $x$ ,  $y$ , and  $z$  are unsigned 32-bit integers.

## 1.8. Type Casting Ininsics

This section describes type casting intrinsic functions that are only supported in device code. To use these functions you do not need to include any additional header files in your program.

### `__device__ float __double2float_rd (double x)`

Convert a double to a float in round-down mode.

#### Returns

Returns converted value.

#### Description

Convert the double-precision floating point value  $x$  to a single-precision floating point value in round-down (to negative infinity) mode.

### `__device__ float __double2float_rn (double x)`

Convert a double to a float in round-to-nearest-even mode.

#### Returns

Returns converted value.

#### Description

Convert the double-precision floating point value  $x$  to a single-precision floating point value in round-to-nearest-even mode.

### `__device__ float __double2float_ru (double x)`

Convert a double to a float in round-up mode.

#### Returns

Returns converted value.

#### Description

Convert the double-precision floating point value  $x$  to a single-precision floating point value in round-up (to positive infinity) mode.

**\_\_device\_\_ float \_\_double2float\_rz (double x)**

Convert a double to a float in round-towards-zero mode.

**Returns**

Returns converted value.

**Description**

Convert the double-precision floating point value  $x$  to a single-precision floating point value in round-towards-zero mode.

**\_\_device\_\_ int \_\_double2hiint (double x)**

Reinterpret high 32 bits in a double as a signed integer.

**Returns**

Returns reinterpreted value.

**Description**

Reinterpret the high 32 bits in the double-precision floating point value  $x$  as a signed integer.

**\_\_device\_\_ int \_\_double2int\_rd (double x)**

Convert a double to a signed int in round-down mode.

**Returns**

Returns converted value.

**Description**

Convert the double-precision floating point value  $x$  to a signed integer value in round-down (to negative infinity) mode.

**\_\_device\_\_ int \_\_double2int\_rn (double x)**

Convert a double to a signed int in round-to-nearest-even mode.

**Returns**

Returns converted value.

**Description**

Convert the double-precision floating point value  $x$  to a signed integer value in round-to-nearest-even mode.

**\_\_device\_\_ int \_\_double2int\_ru (double x)**

Convert a double to a signed int in round-up mode.

**Returns**

Returns converted value.

**Description**

Convert the double-precision floating point value  $x$  to a signed integer value in round-up (to positive infinity) mode.

**\_\_device\_\_ int \_\_double2int\_rz (double)**

Convert a double to a signed int in round-towards-zero mode.

**Returns**

Returns converted value.

**Description**

Convert the double-precision floating point value  $x$  to a signed integer value in round-towards-zero mode.

**\_\_device\_\_ long long int \_\_double2ll\_rd (double x)**

Convert a double to a signed 64-bit int in round-down mode.

**Returns**

Returns converted value.

**Description**

Convert the double-precision floating point value  $x$  to a signed 64-bit integer value in round-down (to negative infinity) mode.

**\_\_device\_\_ long long int \_\_double2ll\_rn (double x)**

Convert a double to a signed 64-bit int in round-to-nearest-even mode.

**Returns**

Returns converted value.

**Description**

Convert the double-precision floating point value  $x$  to a signed 64-bit integer value in round-to-nearest-even mode.

**\_\_device\_\_ long long int \_\_double2ll\_ru (double x)**

Convert a double to a signed 64-bit int in round-up mode.

**Returns**

Returns converted value.

**Description**

Convert the double-precision floating point value  $x$  to a signed 64-bit integer value in round-up (to positive infinity) mode.

**\_\_device\_\_ long long int \_\_double2ll\_rz (double)**

Convert a double to a signed 64-bit int in round-towards-zero mode.

**Returns**

Returns converted value.

**Description**

Convert the double-precision floating point value  $x$  to a signed 64-bit integer value in round-towards-zero mode.

**\_\_device\_\_ int \_\_double2loint (double x)**

Reinterpret low 32 bits in a double as a signed integer.

**Returns**

Returns reinterpreted value.

**Description**

Reinterpret the low 32 bits in the double-precision floating point value  $x$  as a signed integer.

**\_\_device\_\_ unsigned int \_\_double2uint\_rd (double x)**

Convert a double to an unsigned int in round-down mode.

**Returns**

Returns converted value.

**Description**

Convert the double-precision floating point value  $x$  to an unsigned integer value in round-down (to negative infinity) mode.

**\_\_device\_\_ unsigned int \_\_double2uint\_rn (double x)**

Convert a double to an unsigned int in round-to-nearest-even mode.

**Returns**

Returns converted value.

**Description**

Convert the double-precision floating point value  $x$  to an unsigned integer value in round-to-nearest-even mode.

**\_\_device\_\_ unsigned int \_\_double2uint\_ru (double x)**

Convert a double to an unsigned int in round-up mode.

**Returns**

Returns converted value.

**Description**

Convert the double-precision floating point value  $x$  to an unsigned integer value in round-up (to positive infinity) mode.

## `__device__ unsigned int __double2uint_rz (double)`

Convert a double to an unsigned int in round-towards-zero mode.

### Returns

Returns converted value.

### Description

Convert the double-precision floating point value  $x$  to an unsigned integer value in round-towards-zero mode.

## `__device__ unsigned long long int __double2ull_rd (double x)`

Convert a double to an unsigned 64-bit int in round-down mode.

### Returns

Returns converted value.

### Description

Convert the double-precision floating point value  $x$  to an unsigned 64-bit integer value in round-down (to negative infinity) mode.

## `__device__ unsigned long long int __double2ull_rn (double x)`

Convert a double to an unsigned 64-bit int in round-to-nearest-even mode.

### Returns

Returns converted value.

### Description

Convert the double-precision floating point value  $x$  to an unsigned 64-bit integer value in round-to-nearest-even mode.



## `__device__ unsigned long long int __double2ull_ru(double x)`

Convert a double to an unsigned 64-bit int in round-up mode.

### Returns

Returns converted value.

### Description

Convert the double-precision floating point value  $x$  to an unsigned 64-bit integer value in round-up (to positive infinity) mode.

## `__device__ unsigned long long int __double2ull_rz(double)`

Convert a double to an unsigned 64-bit int in round-towards-zero mode.

### Returns

Returns converted value.

### Description

Convert the double-precision floating point value  $x$  to an unsigned 64-bit integer value in round-towards-zero mode.

## `__device__ long long int __double_as_longlong(double x)`

Reinterpret bits in a double as a 64-bit signed integer.

### Returns

Returns reinterpreted value.

### Description

Reinterpret the bits in the double-precision floating point value  $x$  as a signed 64-bit integer.

## `__device__ int __float2int_rd (float x)`

Convert a float to a signed integer in round-down mode.

### Returns

Returns converted value.

### Description

Convert the single-precision floating point value  $x$  to a signed integer in round-down (to negative infinity) mode.

## `__device__ int __float2int_rn (float x)`

Convert a float to a signed integer in round-to-nearest-even mode.

### Returns

Returns converted value.

### Description

Convert the single-precision floating point value  $x$  to a signed integer in round-to-nearest-even mode.

## `__device__ int __float2int_ru (float)`

Convert a float to a signed integer in round-up mode.

### Returns

Returns converted value.

### Description

Convert the single-precision floating point value  $x$  to a signed integer in round-up (to positive infinity) mode.

## `__device__ int __float2int_rz (float x)`

Convert a float to a signed integer in round-towards-zero mode.

### Returns

Returns converted value.

**Description**

Convert the single-precision floating point value  $x$  to a signed integer in round-towards-zero mode.

**\_\_device\_\_ long long int \_\_float2ll\_rd (float x)**

Convert a float to a signed 64-bit integer in round-down mode.

**Returns**

Returns converted value.

**Description**

Convert the single-precision floating point value  $x$  to a signed 64-bit integer in round-down (to negative infinity) mode.

**\_\_device\_\_ long long int \_\_float2ll\_rn (float x)**

Convert a float to a signed 64-bit integer in round-to-nearest-even mode.

**Returns**

Returns converted value.

**Description**

Convert the single-precision floating point value  $x$  to a signed 64-bit integer in round-to-nearest-even mode.

**\_\_device\_\_ long long int \_\_float2ll\_ru (float x)**

Convert a float to a signed 64-bit integer in round-up mode.

**Returns**

Returns converted value.

**Description**

Convert the single-precision floating point value  $x$  to a signed 64-bit integer in round-up (to positive infinity) mode.

**\_\_device\_\_ long long int \_\_float2ll\_rz (float x)**

Convert a float to a signed 64-bit integer in round-towards-zero mode.

**Returns**

Returns converted value.

**Description**

Convert the single-precision floating point value  $x$  to a signed 64-bit integer in round-towards-zero mode.

**\_\_device\_\_ unsigned int \_\_float2uint\_rd (float x)**

Convert a float to an unsigned integer in round-down mode.

**Returns**

Returns converted value.

**Description**

Convert the single-precision floating point value  $x$  to an unsigned integer in round-down (to negative infinity) mode.

**\_\_device\_\_ unsigned int \_\_float2uint\_rn (float x)**

Convert a float to an unsigned integer in round-to-nearest-even mode.

**Returns**

Returns converted value.

**Description**

Convert the single-precision floating point value  $x$  to an unsigned integer in round-to-nearest-even mode.

**\_\_device\_\_ unsigned int \_\_float2uint\_ru (float x)**

Convert a float to an unsigned integer in round-up mode.

**Returns**

Returns converted value.

**Description**

Convert the single-precision floating point value  $x$  to an unsigned integer in round-up (to positive infinity) mode.

**\_\_device\_\_ unsigned int \_\_float2uint\_rz (float x)**

Convert a float to an unsigned integer in round-towards-zero mode.

**Returns**

Returns converted value.

**Description**

Convert the single-precision floating point value  $x$  to an unsigned integer in round-towards-zero mode.

**\_\_device\_\_ unsigned long long int \_\_float2ull\_rd (float x)**

Convert a float to an unsigned 64-bit integer in round-down mode.

**Returns**

Returns converted value.

**Description**

Convert the single-precision floating point value  $x$  to an unsigned 64-bit integer in round-down (to negative infinity) mode.

**\_\_device\_\_ unsigned long long int \_\_float2ull\_rn (float x)**

Convert a float to an unsigned 64-bit integer in round-to-nearest-even mode.

**Returns**

Returns converted value.

**Description**

Convert the single-precision floating point value  $x$  to an unsigned 64-bit integer in round-to-nearest-even mode.

## `__device__ unsigned long long int __float2ull_ru (float x)`

Convert a float to an unsigned 64-bit integer in round-up mode.

### Returns

Returns converted value.

### Description

Convert the single-precision floating point value  $x$  to an unsigned 64-bit integer in round-up (to positive infinity) mode.

## `__device__ unsigned long long int __float2ull_rz (float x)`

Convert a float to an unsigned 64-bit integer in round-towards-zero mode.

### Returns

Returns converted value.

### Description

Convert the single-precision floating point value  $x$  to an unsigned 64-bit integer in round-towards\_zero mode.

## `__device__ int __float_as_int (float x)`

Reinterpret bits in a float as a signed integer.

### Returns

Returns reinterpreted value.

### Description

Reinterpret the bits in the single-precision floating point value  $x$  as a signed integer.

## `__device__ unsigned int __float_as_uint (float x)`

Reinterpret bits in a float as a unsigned integer.

### Returns

Returns reinterpreted value.

**Description**

Reinterpret the bits in the single-precision floating point value  $x$  as a unsigned integer.

**\_\_device\_\_ double \_\_hioint2double (int hi, int lo)**

Reinterpret high and low 32-bit integer values as a double.

**Returns**

Returns reinterpreted value.

**Description**

Reinterpret the integer value of `hi` as the high 32 bits of a double-precision floating point value and the integer value of `lo` as the low 32 bits of the same double-precision floating point value.

**\_\_device\_\_ double \_\_int2double\_rn (int x)**

Convert a signed int to a double.

**Returns**

Returns converted value.

**Description**

Convert the signed integer value  $x$  to a double-precision floating point value.

**\_\_device\_\_ float \_\_int2float\_rd (int x)**

Convert a signed integer to a float in round-down mode.

**Returns**

Returns converted value.

**Description**

Convert the signed integer value  $x$  to a single-precision floating point value in round-down (to negative infinity) mode.

**\_\_device\_\_ float \_\_int2float\_rn (int x)**

Convert a signed integer to a float in round-to-nearest-even mode.

**Returns**

Returns converted value.

**Description**

Convert the signed integer value  $x$  to a single-precision floating point value in round-to-nearest-even mode.

**`__device__ float __int2float_ru (int x)`**

Convert a signed integer to a float in round-up mode.

**Returns**

Returns converted value.

**Description**

Convert the signed integer value  $x$  to a single-precision floating point value in round-up (to positive infinity) mode.

**`__device__ float __int2float_rz (int x)`**

Convert a signed integer to a float in round-towards-zero mode.

**Returns**

Returns converted value.

**Description**

Convert the signed integer value  $x$  to a single-precision floating point value in round-towards-zero mode.

**`__device__ float __int_as_float (int x)`**

Reinterpret bits in an integer as a float.

**Returns**

Returns reinterpreted value.

**Description**

Reinterpret the bits in the signed integer value  $x$  as a single-precision floating point value.



## `__device__ double __ll2double_rd (long long int x)`

Convert a signed 64-bit int to a double in round-down mode.

### Returns

Returns converted value.

### Description

Convert the signed 64-bit integer value  $x$  to a double-precision floating point value in round-down (to negative infinity) mode.

## `__device__ double __ll2double_rn (long long int x)`

Convert a signed 64-bit int to a double in round-to-nearest-even mode.

### Returns

Returns converted value.

### Description

Convert the signed 64-bit integer value  $x$  to a double-precision floating point value in round-to-nearest-even mode.

## `__device__ double __ll2double_ru (long long int x)`

Convert a signed 64-bit int to a double in round-up mode.

### Returns

Returns converted value.

### Description

Convert the signed 64-bit integer value  $x$  to a double-precision floating point value in round-up (to positive infinity) mode.

## `__device__ double __ll2double_rz (long long int x)`

Convert a signed 64-bit int to a double in round-towards-zero mode.

### Returns

Returns converted value.

**Description**

Convert the signed 64-bit integer value  $x$  to a double-precision floating point value in round-towards-zero mode.

**\_\_device\_\_ float \_\_ll2float\_rd (long long int x)**

Convert a signed integer to a float in round-down mode.

**Returns**

Returns converted value.

**Description**

Convert the signed integer value  $x$  to a single-precision floating point value in round-down (to negative infinity) mode.

**\_\_device\_\_ float \_\_ll2float\_rn (long long int x)**

Convert a signed 64-bit integer to a float in round-to-nearest-even mode.

**Returns**

Returns converted value.

**Description**

Convert the signed 64-bit integer value  $x$  to a single-precision floating point value in round-to-nearest-even mode.

**\_\_device\_\_ float \_\_ll2float\_ru (long long int x)**

Convert a signed integer to a float in round-up mode.

**Returns**

Returns converted value.

**Description**

Convert the signed integer value  $x$  to a single-precision floating point value in round-up (to positive infinity) mode.

**\_\_device\_\_ float \_\_ll2float\_rz (long long int x)**

Convert a signed integer to a float in round-towards-zero mode.

**Returns**

Returns converted value.

**Description**

Convert the signed integer value  $x$  to a single-precision floating point value in round-towards-zero mode.

**\_\_device\_\_ double \_\_longlong\_as\_double (long long int x)**

Reinterpret bits in a 64-bit signed integer as a double.

**Returns**

Returns reinterpreted value.

**Description**

Reinterpret the bits in the 64-bit signed integer value  $x$  as a double-precision floating point value.

**\_\_device\_\_ double \_\_uint2double\_rn (unsigned int x)**

Convert an unsigned int to a double.

**Returns**

Returns converted value.

**Description**

Convert the unsigned integer value  $x$  to a double-precision floating point value.

**\_\_device\_\_ float \_\_uint2float\_rd (unsigned int x)**

Convert an unsigned integer to a float in round-down mode.

**Returns**

Returns converted value.

**Description**

Convert the unsigned integer value  $x$  to a single-precision floating point value in round-down (to negative infinity) mode.

**\_\_device\_\_ float \_\_uint2float\_rn (unsigned int x)**

Convert an unsigned integer to a float in round-to-nearest-even mode.

**Returns**

Returns converted value.

**Description**

Convert the unsigned integer value  $x$  to a single-precision floating point value in round-to-nearest-even mode.

**\_\_device\_\_ float \_\_uint2float\_ru (unsigned int x)**

Convert an unsigned integer to a float in round-up mode.

**Returns**

Returns converted value.

**Description**

Convert the unsigned integer value  $x$  to a single-precision floating point value in round-up (to positive infinity) mode.

**\_\_device\_\_ float \_\_uint2float\_rz (unsigned int x)**

Convert an unsigned integer to a float in round-towards-zero mode.

**Returns**

Returns converted value.

**Description**

Convert the unsigned integer value  $x$  to a single-precision floating point value in round-towards-zero mode.

**\_\_device\_\_ float \_\_uint\_as\_float (unsigned int x)**

Reinterpret bits in an unsigned integer as a float.

**Returns**

Returns reinterpreted value.

**Description**

Reinterpret the bits in the unsigned integer value  $x$  as a single-precision floating point value.

**\_\_device\_\_ double \_\_ull2double\_rd (unsigned long long int x)**

Convert an unsigned 64-bit int to a double in round-down mode.

**Returns**

Returns converted value.

**Description**

Convert the unsigned 64-bit integer value  $x$  to a double-precision floating point value in round-down (to negative infinity) mode.

**\_\_device\_\_ double \_\_ull2double\_rn (unsigned long long int x)**

Convert an unsigned 64-bit int to a double in round-to-nearest-even mode.

**Returns**

Returns converted value.

**Description**

Convert the unsigned 64-bit integer value  $x$  to a double-precision floating point value in round-to-nearest-even mode.

## `__device__ double __ull2double_ru (unsigned long long int x)`

Convert an unsigned 64-bit int to a double in round-up mode.

### Returns

Returns converted value.

### Description

Convert the unsigned 64-bit integer value  $x$  to a double-precision floating point value in round-up (to positive infinity) mode.

## `__device__ double __ull2double_rz (unsigned long long int x)`

Convert an unsigned 64-bit int to a double in round-towards-zero mode.

### Returns

Returns converted value.

### Description

Convert the unsigned 64-bit integer value  $x$  to a double-precision floating point value in round-towards-zero mode.

## `__device__ float __ull2float_rd (unsigned long long int x)`

Convert an unsigned integer to a float in round-down mode.

### Returns

Returns converted value.

### Description

Convert the unsigned integer value  $x$  to a single-precision floating point value in round-down (to negative infinity) mode.

## `__device__ float __ull2float_rn (unsigned long long int x)`

Convert an unsigned integer to a float in round-to-nearest-even mode.

### Returns

Returns converted value.

### Description

Convert the unsigned integer value  $x$  to a single-precision floating point value in round-to-nearest-even mode.

## `__device__ float __ull2float_ru (unsigned long long int x)`

Convert an unsigned integer to a float in round-up mode.

### Returns

Returns converted value.

### Description

Convert the unsigned integer value  $x$  to a single-precision floating point value in round-up (to positive infinity) mode.

## `__device__ float __ull2float_rz (unsigned long long int x)`

Convert an unsigned integer to a float in round-towards-zero mode.

### Returns

Returns converted value.

### Description

Convert the unsigned integer value  $x$  to a single-precision floating point value in round-towards-zero mode.

## 1.9. SIMD Intrinsics

This section describes SIMD intrinsic functions that are only supported in device code. To use these functions you do not need to include any additional header files in your program.

### `__device__ unsigned int __vabs2 (unsigned int a)`

Computes per-halfword absolute value.

#### Returns

Returns computed value.

#### Description

Splits 4 bytes of argument into 2 parts, each consisting of 2 bytes, then computes absolute value for each of parts. Result is stored as unsigned int and returned.

### `__device__ unsigned int __vabs4 (unsigned int a)`

Computes per-byte absolute value.

#### Returns

Returns computed value.

#### Description

Splits argument by bytes. Computes absolute value of each byte. Result is stored as unsigned int.

### `__device__ unsigned int __vabsdiffs2 (unsigned int a, unsigned int b)`

Computes per-halfword sum of absolute difference of signed integer.

#### Returns

Returns computed value.

#### Description

Splits 4 bytes of each into 2 parts, each consisting of 2 bytes. For corresponding parts function computes absolute difference. Result is stored as unsigned int and returned.



## **\_\_device\_\_ unsigned int \_\_vabsdiffs4 (unsigned int a, unsigned int b)**

Computes per-byte absolute difference of signed integer.

### **Returns**

Returns computed value.

### **Description**

Splits 4 bytes of each into 4 parts, each consisting of 1 byte. For corresponding parts function computes absolute difference. Result is stored as unsigned int and returned.

## **\_\_device\_\_ unsigned int \_\_vabsdiffu2 (unsigned int a, unsigned int b)**

Performs per-halfword absolute difference of unsigned integer computation:  $|a - b|$ .

### **Returns**

Returns computed value.

### **Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function computes absolute difference. Result is stored as unsigned int and returned.

## **\_\_device\_\_ unsigned int \_\_vabsdiffu4 (unsigned int a, unsigned int b)**

Computes per-byte absolute difference of unsigned integer.

### **Returns**

Returns computed value.

### **Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function computes absolute difference. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vabsss2 (unsigned int a)`

Computes per-halfword absolute value with signed saturation.

### Returns

Returns computed value.

### Description

Splits 4 bytes of argument into 2 parts, each consisting of 2 bytes, then computes absolute value with signed saturation for each of parts. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vabsss4 (unsigned int a)`

Computes per-byte absolute value with signed saturation.

### Returns

Returns computed value.

### Description

Splits 4 bytes of argument into 4 parts, each consisting of 1 byte, then computes absolute value with signed saturation for each of parts. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vadd2 (unsigned int a, unsigned int b)`

Performs per-halfword (un)signed addition, with wrap-around:  $a + b$ .

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes, then performs unsigned addition on corresponding parts. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vadd4 (unsigned int a, unsigned int b)`

Performs per-byte (un)signed addition.

### Returns

Returns computed value.

### Description

Splits 'a' into 4 bytes, then performs unsigned addition on each of these bytes with the corresponding byte from 'b', ignoring overflow. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vaddss2 (unsigned int a, unsigned int b)`

Performs per-halfword addition with signed saturation.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes, then performs addition with signed saturation on corresponding parts. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vaddss4 (unsigned int a, unsigned int b)`

Performs per-byte addition with signed saturation.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte, then performs addition with signed saturation on corresponding parts. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vaddus2 (unsigned int a, unsigned int b)`

Performs per-halfword addition with unsigned saturation.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes, then performs addition with unsigned saturation on corresponding parts.

## `__device__ unsigned int __vaddus4 (unsigned int a, unsigned int b)`

Performs per-byte addition with unsigned saturation.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte, then performs addition with unsigned saturation on corresponding parts.

## `__device__ unsigned int __vavgs2 (unsigned int a, unsigned int b)`

Performs per-halfword signed rounded average computation.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. then computes signed rounded average of corresponding parts. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vavgs4 (unsigned int a, unsigned int b)`

Computes per-byte signed rounder average.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. then computes signed rounded avarege of corresponding parts. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vavgu2 (unsigned int a, unsigned int b)`

Performs per-halfword unsigned rounded average computation.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. then computes unsigned rounded avarege of corresponding parts. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vavgu4 (unsigned int a, unsigned int b)`

Performs per-byte unsigned rounded average.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. then computes unsigned rounded avarege of corresponding parts. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vcmpeq2 (unsigned int a, unsigned int b)`

Performs per-halfword (un)signed comparison.

### Returns

Returns 0xffff computed value.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts result is ffff if they are equal, and 0000 otherwise. For example `__vcmpeq2(0x1234aba5, 0x1234aba6)` returns 0xffff0000.

## `__device__ unsigned int __vcmpq4 (unsigned int a, unsigned int b)`

Performs per-byte (un)signed comparison.

### Returns

Returns 0xff if a = b, else returns 0.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts result is ff if they are equal, and 00 otherwise. For example `__vcmpq4(0x1234aba5, 0x1234aba6)` returns 0xffffff00.

## `__device__ unsigned int __vcmpges2 (unsigned int a, unsigned int b)`

Performs per-halfword signed comparison:  $a \geq b ? 0xffff : 0$ .

### Returns

Returns 0xffff if  $a \geq b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts result is ffff if 'a' part  $\geq$  'b' part, and 0000 otherwise. For example `__vcmpges2(0x1234aba5, 0x1234aba6)` returns 0xffff0000.

## `__device__ unsigned int __vcmpges4 (unsigned int a, unsigned int b)`

Performs per-byte signed comparison.

### Returns

Returns 0xff if  $a \geq b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts result is ff if 'a' part  $\geq$  'b' part, and 00 otherwise. For example `__vcmpges4(0x1234aba5, 0x1234aba6)` returns 0xffffff00.

## `__device__ unsigned int __vcmpgeu2 (unsigned int a, unsigned int b)`

Performs per-halfword unsigned comparison:  $a \geq b ? 0xffff : 0$ .

### Returns

Returns 0xffff if  $a \geq b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts result is ffff if 'a' part  $\geq$  'b' part, and 0000 otherwise. For example `__vcmpgeu2(0x1234aba5, 0x1234aba6)` returns 0xffff0000.

## `__device__ unsigned int __vcmpgeu4 (unsigned int a, unsigned int b)`

Performs per-byte unsigned comparison.

### Returns

Returns 0xff if  $a \geq b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts result is ff if 'a' part  $\geq$  'b' part, and 00 otherwise. For example `__vcmpgeu4(0x1234aba5, 0x1234aba6)` returns 0xffffff00.

## `__device__ unsigned int __vcmpgts2 (unsigned int a, unsigned int b)`

Performs per-halfword signed comparison:  $a > b ? 0xffff : 0$ .

### Returns

Returns 0xffff if  $a > b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts result is ffff if 'a' part > 'b' part, and 0000 otherwise. For example `__vcmpgts2(0x1234aba5, 0x1234aba6)` returns 0x00000000.

## `__device__ unsigned int __vcmpgts4 (unsigned int a, unsigned int b)`

Performs per-byte signed comparison.

### Returns

Returns 0xff if  $a > b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts result is ff if 'a' part > 'b' part, and 00 otherwise. For example `__vcmpgts4(0x1234aba5, 0x1234aba6)` returns 0x00000000.

## `__device__ unsigned int __vcmpgtu2 (unsigned int a, unsigned int b)`

Performs per-halfword unsigned comparison:  $a > b ? 0xffff : 0$ .

### Returns

Returns 0xffff if  $a > b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts result is ffff if 'a' part > 'b' part, and 0000 otherwise. For example `__vcmpgtu2(0x1234aba5, 0x1234aba6)` returns 0x00000000.



## `__device__ unsigned int __vcmpgtu4 (unsigned int a, unsigned int b)`

Performs per-byte unsigned comparison.

### Returns

Returns 0xff if  $a > b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts result is ff if 'a' part > 'b' part, and 00 otherwise. For example `__vcmpgtu4(0x1234aba5, 0x1234aba6)` returns 0x00000000.

## `__device__ unsigned int __vcmpl2 (unsigned int a, unsigned int b)`

Performs per-halfword signed comparison:  $a \leq b ? 0xffff : 0$ .

### Returns

Returns 0xffff if  $a \leq b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts result is ffff if 'a' part  $\leq$  'b' part, and 0000 otherwise. For example `__vcmpl2(0x1234aba5, 0x1234aba6)` returns 0xffffffff.

## `__device__ unsigned int __vcmpl4 (unsigned int a, unsigned int b)`

Performs per-byte signed comparison.

### Returns

Returns 0xff if  $a \leq b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts result is ff if 'a' part  $\leq$  'b' part, and 00 otherwise. For example `__vcmpl4(0x1234aba5, 0x1234aba6)` returns 0xffffffff.

## `__device__ unsigned int __vcmpleu2 (unsigned int a, unsigned int b)`

Performs per-halfword unsigned comparison:  $a \leq b ? 0xffff : 0$ .

### Returns

Returns 0xffff if  $a \leq b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts result is ffff if 'a' part  $\leq$  'b' part, and 0000 otherwise. For example `__vcmpleu2(0x1234aba5, 0x1234aba6)` returns 0xffffffff.

## `__device__ unsigned int __vcmpleu4 (unsigned int a, unsigned int b)`

Performs per-byte unsigned comparison.

### Returns

Returns 0xff if  $a \leq b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts result is ff if 'a' part  $\leq$  'b' part, and 00 otherwise. For example `__vcmpleu4(0x1234aba5, 0x1234aba6)` returns 0xffffffff.

## `__device__ unsigned int __vcmplt2 (unsigned int a, unsigned int b)`

Performs per-halfword signed comparison:  $a < b ? 0xffff : 0$ .

### Returns

Returns 0xffff if  $a < b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts result is ffff if 'a' part  $<$  'b' part, and 0000 otherwise. For example `__vcmplt2(0x1234aba5, 0x1234aba6)` returns 0x0000ffff.

## `__device__ unsigned int __vcmplt4 (unsigned int a, unsigned int b)`

Performs per-byte signed comparison.

### Returns

Returns 0xff if  $a < b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts result is ff if 'a' part < 'b' part, and 00 otherwise. For example `__vcmplt4(0x1234aba5, 0x1234aba6)` returns 0x000000ff.

## `__device__ unsigned int __vcmltu2 (unsigned int a, unsigned int b)`

Performs per-halfword unsigned comparison:  $a < b ? 0xffff : 0$ .

### Returns

Returns 0xffff if  $a < b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts result is ffff if 'a' part < 'b' part, and 0000 otherwise. For example `__vcmltu2(0x1234aba5, 0x1234aba6)` returns 0x0000ffff.

## `__device__ unsigned int __vcmltu4 (unsigned int a, unsigned int b)`

Performs per-byte unsigned comparison.

### Returns

Returns 0xff if  $a < b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts result is ff if 'a' part < 'b' part, and 00 otherwise. For example `__vcmltu4(0x1234aba5, 0x1234aba6)` returns 0x000000ff.

## `__device__ unsigned int __vcmpne2 (unsigned int a, unsigned int b)`

Performs per-halfword (un)signed comparison:  $a \neq b ? 0xffff : 0$ .

### Returns

Returns 0xffff if  $a \neq b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts result is ffff if 'a' part  $\neq$  'b' part, and 0000 otherwise. For example `__vcmplt2(0x1234aba5, 0x1234aba6)` returns 0x0000ffff.

## `__device__ unsigned int __vcmpne4 (unsigned int a, unsigned int b)`

Performs per-byte (un)signed comparison.

### Returns

Returns 0xff if  $a \neq b$ , else returns 0.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts result is ff if 'a' part  $\neq$  'b' part, and 00 otherwise. For example `__vcmplt4(0x1234aba5, 0x1234aba6)` returns 0x000000ff.

## `__device__ unsigned int __vhaddu2 (unsigned int a, unsigned int b)`

Performs per-halfword unsigned average computation.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. then computes unsigned average of corresponding parts. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vhaddu4 (unsigned int a, unsigned int b)`

Computes per-byte unsigned average.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. then computes unsigned average of corresponding parts. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vmaxs2 (unsigned int a, unsigned int b)`

Performs per-halfword signed maximum computation.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function computes signed maximum. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vmaxs4 (unsigned int a, unsigned int b)`

Computes per-byte signed maximum.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function computes signed maximum. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vmaxu2 (unsigned int a, unsigned int b)`

Performs per-halfword unsigned maximum computation.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function computes unsigned maximum. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vmaxu4 (unsigned int a, unsigned int b)`

Computes per-byte unsigned maximum.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function computes unsigned maximum. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vmins2 (unsigned int a, unsigned int b)`

Performs per-halfword signed minimum computation.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function computes signed minimum. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vmins4 (unsigned int a, unsigned int b)`

Computes per-byte signed minimum.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function computes signed minimum. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vminu2 (unsigned int a, unsigned int b)`

Performs per-halfword unsigned minimum computation.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function computes unsigned minimum. Result is stored as unsigned int and returned.

## `__device__ unsigned int __vminu4 (unsigned int a, unsigned int b)`

Computes per-byte unsigned minimum.

### Returns

Returns computed value.

### Description

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function computes unsigned minimum. Result is stored as unsigned int and returned.

**\_\_device\_\_ unsigned int \_\_vneg2 (unsigned int a)**

Computes per-halfword negation.

**Returns**

Returns computed value.

**Description**

Splits 4 bytes of argument into 2 parts, each consisting of 2 bytes. For each part function computes negation. Result is stored as unsigned int and returned.

**\_\_device\_\_ unsigned int \_\_vneg4 (unsigned int a)**

Performs per-byte negation.

**Returns**

Returns computed value.

**Description**

Splits 4 bytes of argument into 4 parts, each consisting of 1 byte. For each part function computes negation. Result is stored as unsigned int and returned.

**\_\_device\_\_ unsigned int \_\_vnegss2 (unsigned int a)**

Computes per-halfword negation with signed saturation.

**Returns**

Returns computed value.

**Description**

Splits 4 bytes of argument into 2 parts, each consisting of 2 bytes. For each part function computes negation. Result is stored as unsigned int and returned.

**\_\_device\_\_ unsigned int \_\_vnegss4 (unsigned int a)**

Performs per-byte negation with signed saturation.

**Returns**

Returns computed value.



**Description**

Splits 4 bytes of argument into 4 parts, each consisting of 1 byte. For each part function computes negation. Result is stored as unsigned int and returned.

**\_\_device\_\_ unsigned int \_\_vsads2 (unsigned int a, unsigned int b)**

Performs per-halfword sum of absolute difference of signed.

**Returns**

Returns computed value.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts functions computes absolute difference and sum it up. Result is stored as unsigned int and returned.

**\_\_device\_\_ unsigned int \_\_vsads4 (unsigned int a, unsigned int b)**

Computes per-byte sum of abs difference of signed.

**Returns**

Returns computed value.

**Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts functions computes absolute difference and sum it up. Result is stored as unsigned int and returned.

**\_\_device\_\_ unsigned int \_\_vsadu2 (unsigned int a, unsigned int b)**

Computes per-halfword sum of abs diff of unsigned.

**Returns**

Returns computed value.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function computes absolute differences, and returns sum of those differences.

**\_\_device\_\_ unsigned int \_\_vsadu4 (unsigned int a, unsigned int b)**

Computes per-byte sum of abs difference of unsigned.

**Returns**

Returns computed value.

**Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function computes absolute differences, and returns sum of those differences.

**\_\_device\_\_ unsigned int \_\_vseteq2 (unsigned int a, unsigned int b)**

Performs per-halfword (un)signed comparison.

**Returns**

Returns 1 if a = b, else returns 0.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function performs comparison 'a' part == 'b' part. If both equalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vseteq4 (unsigned int a, unsigned int b)**

Performs per-byte (un)signed comparison.

**Returns**

Returns 1 if a = b, else returns 0.

**Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function performs comparison 'a' part == 'b' part. If both equalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetges2 (unsigned int a, unsigned int b)**

Performs per-halfword signed comparison.

**Returns**

Returns 1 if  $a \geq b$ , else returns 0.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function performs comparison 'a' part  $\geq$  'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetges4 (unsigned int a, unsigned int b)**

Performs per-byte signed comparison.

**Returns**

Returns 1 if  $a \geq b$ , else returns 0.

**Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function performs comparison 'a' part  $\geq$  'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetgeu2 (unsigned int a, unsigned int b)**

Performs per-halfword unsigned minimum unsigned comparison.

**Returns**

Returns 1 if  $a \geq b$ , else returns 0.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function performs comparison 'a' part  $\geq$  'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetgeu4 (unsigned int a, unsigned int b)**

Performs per-byte unsigned comparison.

**Returns**

Returns 1 if  $a \geq b$ , else returns 0.

**Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function performs comparison 'a' part  $\geq$  'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetgts2 (unsigned int a, unsigned int b)**

Performs per-halfword signed comparison.

**Returns**

Returns 1 if  $a > b$ , else returns 0.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function performs comparison 'a' part  $>$  'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetgts4 (unsigned int a, unsigned int b)**

Performs per-byte signed comparison.

**Returns**

Returns 1 if  $a > b$ , else returns 0.

**Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function performs comparison 'a' part > 'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetgtu2 (unsigned int a, unsigned int b)**

Performs per-halfword unsigned comparison.

**Returns**

Returns 1 if a > b, else returns 0.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function performs comparison 'a' part > 'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetgtu4 (unsigned int a, unsigned int b)**

Performs per-byte unsigned comparison.

**Returns**

Returns 1 if a > b, else returns 0.

**Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function performs comparison 'a' part > 'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetles2 (unsigned int a, unsigned int b)**

Performs per-halfword unsigned minimum computation.

**Returns**

Returns 1 if a <= b, else returns 0.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function performs comparison 'a' part <= 'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetles4 (unsigned int a, unsigned int b)**

Performs per-byte signed comparison.

**Returns**

Returns 1 if a <= b, else returns 0.

**Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function performs comparison 'a' part <= 'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetleu2 (unsigned int a, unsigned int b)**

Performs per-halfword signed comparison.

**Returns**

Returns 1 if a <= b, else returns 0.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function performs comparison 'a' part <= 'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetleu4 (unsigned int a, unsigned int b)**

Performs per-byte unsigned comparison.

**Returns**

Returns 1 if a <= b, else returns 0.

**Description**

Splits 4 bytes of each argument into 4 part, each consisting of 1 byte. For corresponding parts function performs comparison 'a' part <= 'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetlts2 (unsigned int a, unsigned int b)**

Performs per-halfword signed comparison.

**Returns**

Returns 1 if  $a < b$ , else returns 0.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function performs comparison 'a' part <= 'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetlts4 (unsigned int a, unsigned int b)**

Performs per-byte signed comparison.

**Returns**

Returns 1 if  $a < b$ , else returns 0.

**Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function performs comparison 'a' part <= 'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetltu2 (unsigned int a, unsigned int b)**

Performs per-halfword unsigned comparison.

**Returns**

Returns 1 if  $a < b$ , else returns 0.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function performs comparison 'a' part <= 'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetltu4 (unsigned int a, unsigned int b)**

Performs per-byte unsigned comparison.

**Returns**

Returns 1 if a < b, else returns 0.

**Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function performs comparison 'a' part <= 'b' part. If both inequalities are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetne2 (unsigned int a, unsigned int b)**

Performs per-halfword (un)signed comparison.

**Returns**

Returns 1 if a != b, else returns 0.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts function performs comparison 'a' part != 'b' part. If both conditions are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsetne4 (unsigned int a, unsigned int b)**

Performs per-byte (un)signed comparison.

**Returns**

Returns 1 if a != b, else returns 0.



**Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts function performs comparison 'a' part != 'b' part. If both conditions are satisfied, function returns 1.

**\_\_device\_\_ unsigned int \_\_vsub2 (unsigned int a, unsigned int b)**

Performs per-halfword (un)signed subtraction, with wrap-around.

**Returns**

Returns computed value.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts functions performs subtraction. Result is stored as unsigned int and returned.

**\_\_device\_\_ unsigned int \_\_vsub4 (unsigned int a, unsigned int b)**

Performs per-byte subtraction.

**Returns**

Returns computed value.

**Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts functions performs subtraction. Result is stored as unsigned int and returned.

**\_\_device\_\_ unsigned int \_\_vsubss2 (unsigned int a, unsigned int b)**

Performs per-halfword (un)signed subtraction, with signed saturation.

**Returns**

Returns computed value.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts functions performs subtraction with signed saturation. Result is stored as unsigned int and returned.

**\_\_device\_\_ unsigned int \_\_vsubss4 (unsigned int a, unsigned int b)**

Performs per-byte subtraction with signed saturation.

**Returns**

Returns computed value.

**Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts functions performs subtraction with signed saturation. Result is stored as unsigned int and returned.

**\_\_device\_\_ unsigned int \_\_vsubus2 (unsigned int a, unsigned int b)**

Performs per-halfword subtraction with unsigned saturation.

**Returns**

Returns computed value.

**Description**

Splits 4 bytes of each argument into 2 parts, each consisting of 2 bytes. For corresponding parts functions performs subtraction with unsigned saturation. Result is stored as unsigned int and returned.

**\_\_device\_\_ unsigned int \_\_vsubus4 (unsigned int a, unsigned int b)**

Performs per-byte subtraction with unsigned saturation.

**Returns**

Returns computed value.

**Description**

Splits 4 bytes of each argument into 4 parts, each consisting of 1 byte. For corresponding parts functions performs subtraction with unsigned saturation. Result is stored as unsigned int and returned.

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