C/C++ Rounding Cheat Sheet

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Introduction

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- C/C++ are mostly the same
- Rounding mode independent: `floor*`, `ceil*`, ...
- Rounding mode dependent: `rint*`, `nearbyint*`, ...

Floating Point Environment

- `<fenv.h>` / `<cfenv>`

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- `fesetround(FE_TONEAREST)`, `fegetround()`

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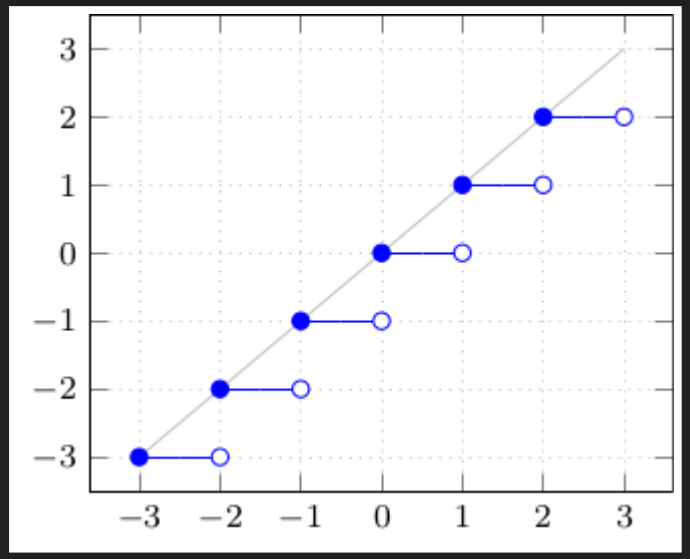
Floating Point Environment

- `<fenv.h>`/`<cfenv>`
- `fesetround(FE_TONEAREST)`, `fegetround()`
- `fetestexcept(mask)`, `feclearexcept(mask)`
- `FE_INVALID`, `FE_INEXACT`, `FE_ALL_EXCEPT`, …

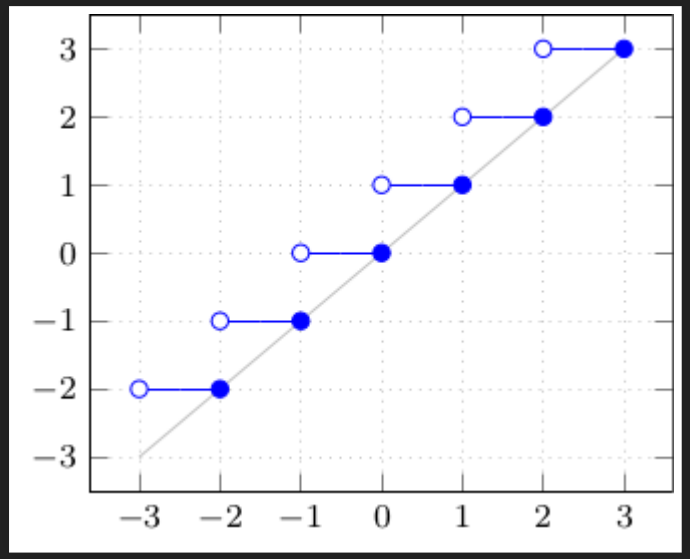
Floor




```
C:
  double floor(double);
  float floorf(float);
  long double floorl(long double);

C++: T={float, double, long double}
  T std::floor(T);

C++11:
  float std::floorf(float);
  long double std::floorl(long double);
  double std::floor(IntegralType);
```

- `(long int)floor(x);` / `floorf` / …
- Corresponding rounding mode: `FE_DOWNWARD`

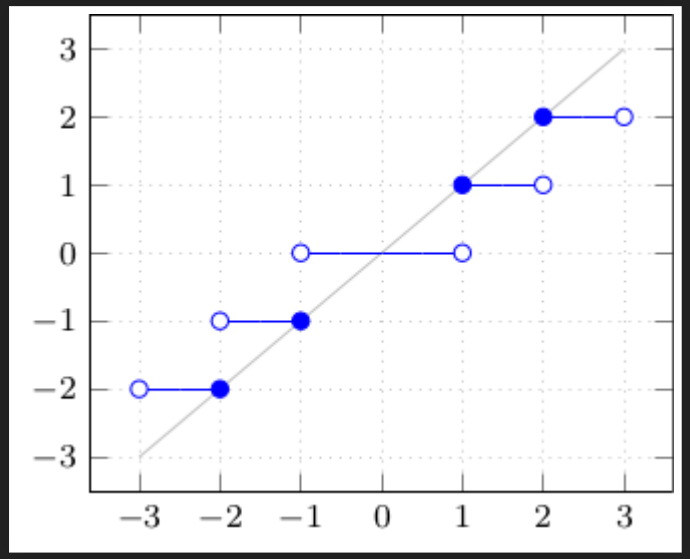
Ceil




```
C:
  double ceil(double);
  float ceilf(float);
  long double ceill(long double);

C++: T={float, double, long double}
  T std::ceil(T);

C++11:
  float std::ceilf(float);
  long double std::ceill(long double);
  double std::ceil(IntegralType);
```

- `(long int)ceil(x);` / …
- Corresponding rounding mode: `FE_UPWARD`

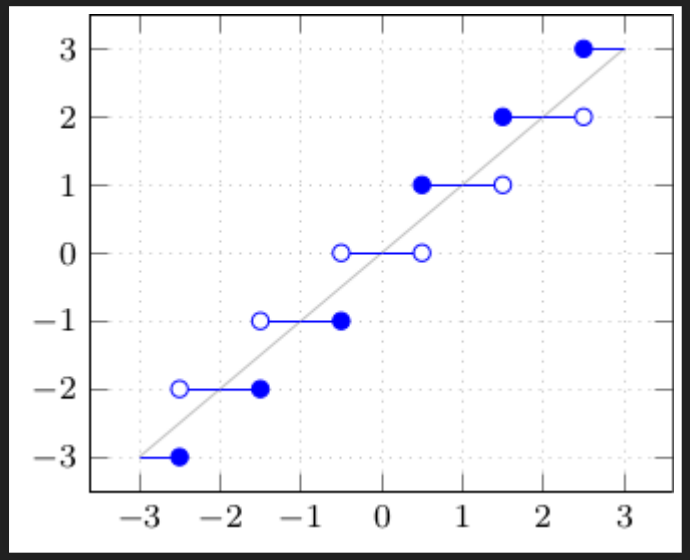
Truncate / Round toward zero




```
C:
  double trunc(double);
  float truncf(float);
  long double truncl(long double);

C++11: T={float, double, long double}
  T std::trunc(T);

  float std::truncf(float);
  long double std::truncl(long double);
  double std::trunc(IntegralType);
```

- `(long int)x;`
- Corresponding rounding mode: `FE_TOWARDZERO`

Round to nearest, halfway cases away from zero

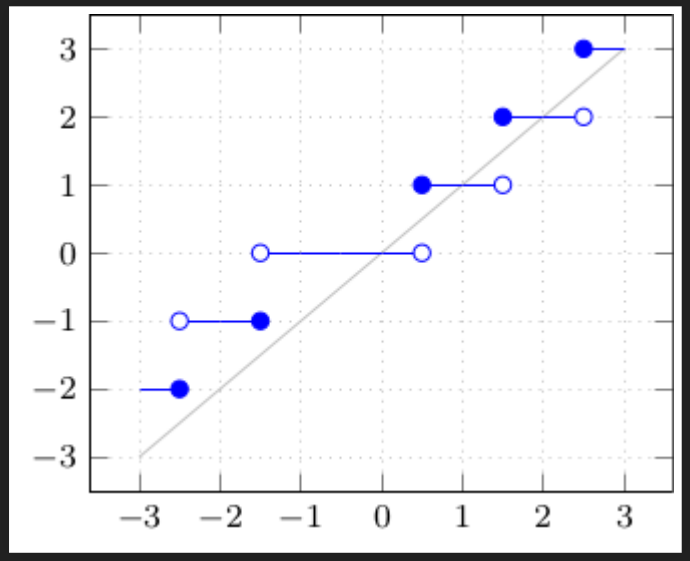



```
C:
  double round(double); / float roundf(
  long int lround(double); / lroundf / l
  long long int llround(double); / ...

C++11: T={float, double, long double}
  T std::round(T);
  long std::lround(T); / long long std:

  double std::round(IntegralType); / lo
```

- No (standardized) corresponding rounding mode!

Round to nearest, halfway cases away from zero

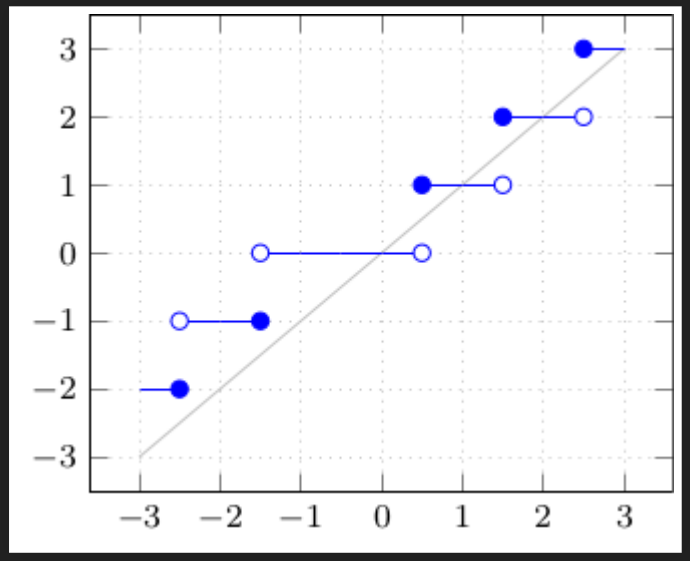
- How NOT to do it -




```
(long int)(x + 0.5);
```

Round to nearest, halfway cases away from zero

- How NOT to do it -

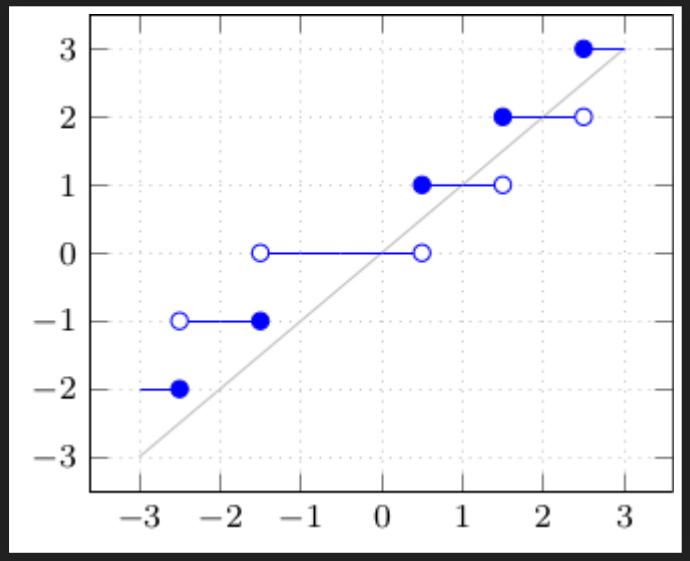



```
(long int)(x + 0.5);
```

- Problem 1: < 0

Round to nearest, halfway cases away from zero

- How NOT to do it -

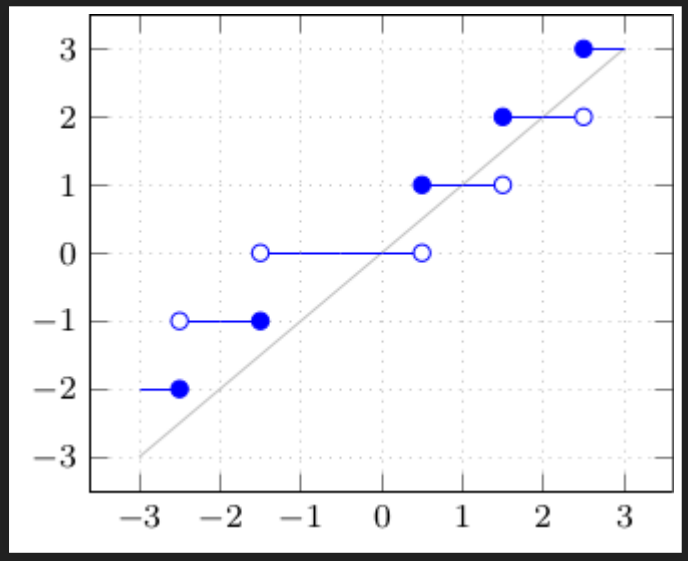



```
(long int)(x + 0.5);
```

- Problem 1: < 0
- Problem 2: $\geq 2^{23}$ (float)

Round to nearest, halfway cases away from zero

- How NOT to do it -

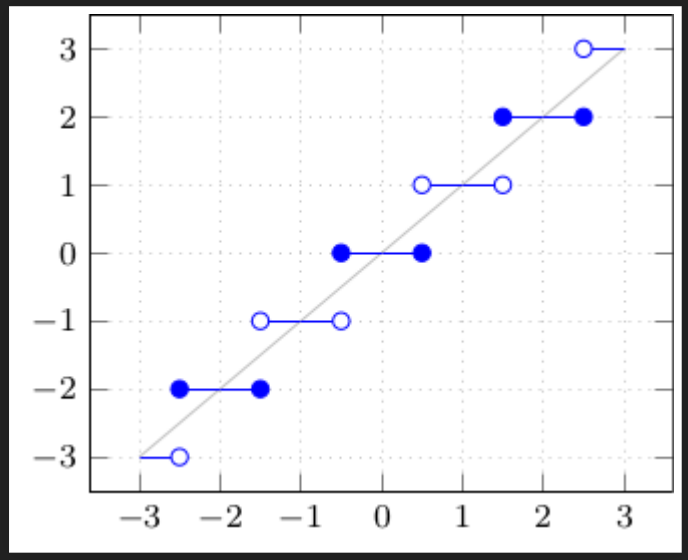



```
(long int)(x + 0.5);
```

- Problem 1: < 0
- Problem 2: $\geq 2^{23}$ (float)

- And more...: "Harder than it looks: rounding float to nearest integer, part 1"

Round to nearest, halfway cases to even




```
Rounding mode dependent methods (C / C+
  double rint(double); / rintf / rintl
  T rint(T / IntegralType);

  long lrint(T / IntegralType); / llrin

  T nearbyint(T / IntegralType);

Less commonly available (C only):
  double roundeven(double); / roundeven
```

- `(long int)roundeven(x);` / …
- Corresponding rounding mode: `FE_TOWARDZERO`

Round to nearest, halfway cases upward

- `(long int)floor(x + 0.5);/`
  `(long int)floorf(x + 0.5f);`

Round to nearest, halfway cases upward

- `(long int)floor(x + 0.5);/`
  `(long int)floorf(x + 0.5f);`
- Has most problems of round-nearest by cast.

Round to nearest, halfway cases upward

- `(long int)floor(x + 0.5);/`
  `(long int)floorf(x + 0.5f);`
- Has most problems of round-nearest by cast.
- Better: Use "halfway cases to even"!

Rounding mode dependent

```
C / C++11:
  rint* - does not raise FE_INEXACT

  nearbyint* - raises FE_INEXACT

  long lrint*, long long llrint*
   - like lround / llround
   - FE_INEXACT is also a domain error (FE_INVALID)
```

Other languages

```
Javascript:
  x|0;   => trunc/cast (limited to 32 bit!)
  Math.round(x);   => Round to nearest, halfway cases upwards
  x.fixed(digits);  - halfway cases are not fully reliable!
  Math.floor(x); / Math.ceil(x);
```

Other languages

```
Javascript:
  x|0;    => trunc/cast (limited to 32 bit!)
  Math.round(x);    => Round to nearest, halfway cases upwards
  x.fixed(digits);  - halfway cases are not fully reliable!
  Math.floor(x); / Math.ceil(x);
```

```
PHP:
  $x|0; / intval($x) / (int)$x / (integer)$x;
   => trunc/cast (limited to 32 / 64 bit!)

  round($x,$precision=0,$mode=PHP_ROUND_HALF_UP)
    - $mode=_HALF_UP | _HALF_DOWN | _HALF_EVEN | _HALF_ODD
      since PHP 5.3

  floor($x); / ceil($x);
```

Links, Fragen?

- Harder than it looks: rounding float to nearest integer, part 1: http://blog.frama-c.com/index.php?post/2013/05/02/nearbyintf1
- Cheat sheet: https://thax.hardliners.org/rounding/
- Slides: https://smilingthax.github.io/slides/rounding/