

**NAME**

Math::BigInt - Arbitrary size integer/float math package

**SYNOPSIS**

```
use Math::BigInt;

# or make it faster: install (optional) Math::BigInt::GMP
# and always use (it will fall back to pure Perl if the
# GMP library is not installed):

use Math::BigInt lib => 'GMP';

my $str = '1234567890';
my @values = (64,74,18);
my $n = 1; my $sign = '-';

# Number creation
$x = Math::BigInt->new($str); # defaults to 0
$y = $x->copy(); # make a true copy
$nan = Math::BigInt->bnan(); # create a NotANumber
$zero = Math::BigInt->bzero(); # create a +0
$inf = Math::BigInt->binf(); # create a +inf
$inf = Math::BigInt->binf('-'); # create a -inf
$one = Math::BigInt->bone(); # create a +1
$one = Math::BigInt->bone('-'); # create a -1

# Testing (don't modify their arguments)
# (return true if the condition is met, otherwise false)

$x->is_zero(); # if $x is +0
$x->is_nan(); # if $x is NaN
$x->is_one(); # if $x is +1
$x->is_one('-'); # if $x is -1
$x->is_odd(); # if $x is odd
$x->is_even(); # if $x is even
$x->is_pos(); # if $x >= 0
$x->is_neg(); # if $x < 0
$x->is_inf($sign); # if $x is +inf, or -inf (sign is default '+')
$x->is_int(); # if $x is an integer (not a float)

# comparing and digit/sign extration
$x->bcmp($y); # compare numbers (undef,<0,=0,>0)
$x->bacmp($y); # compare absolutely (undef,<0,=0,>0)
$x->sign(); # return the sign, either +,- or NaN
$x->digit($n); # return the nth digit, counting from right
$x->digit(-$n); # return the nth digit, counting from left

# The following all modify their first argument. If you want to preserve
# $x, use $z = $x->copy()->bXXX($y); See under L<CAVEATS> for why this is
# necessary when mixing $a = $b assignments with non-overloaded math.

$x->bzero(); # set $x to 0
$x->bnan(); # set $x to NaN
```

```
$x->bone(); # set $x to +1
$x->bone('-'); # set $x to -1
$x->binf(); # set $x to inf
$x->binf('-'); # set $x to -inf

$x->bneg(); # negation
$x->babs(); # absolute value
$x->bnorm(); # normalize (no-op in BigInt)
$x->bnot(); # two's complement (bit wise not)
$x->binc(); # increment $x by 1
$x->bdec(); # decrement $x by 1

$x->badd($y); # addition (add $y to $x)
$x->bsub($y); # subtraction (subtract $y from $x)
$x->bmul($y); # multiplication (multiply $x by $y)
$x->bdiv($y); # divide, set $x to quotient
# return (quo,rem) or quo if scalar

$x->bmod($y); # modulus (x % y)
$x->bmodpow($exp,$mod); # modular exponentiation (($num**$exp) % $mod)
$x->bmodinv($mod); # the inverse of $x in the given modulus $mod

$x->bpow($y); # power of arguments (x ** y)
$x->blsft($y); # left shift
$x->brsft($y); # right shift
$x->blsft($y,$n); # left shift, by base $n (like 10)
$x->brsft($y,$n); # right shift, by base $n (like 10)

$x->band($y); # bitwise and
$x->bior($y); # bitwise inclusive or
$x->bxor($y); # bitwise exclusive or
$x->bnot(); # bitwise not (two's complement)

$x->bsqrt(); # calculate square-root
$x->broot($y); # $y'th root of $x (e.g. $y == 3 => cubic root)
$x->bfac(); # factorial of $x (1*2*3*4*...*x)

$x->round($A,$P,$mode); # round to accuracy or precision using mode
$mode
$x->bround($n); # accuracy: preserve $n digits
$x->bround($n); # round to $nth digit, no-op for BigInts

# The following do not modify their arguments in BigInt (are no-ops),
# but do so in BigFloat:

$x->bfloor(); # return integer less or equal than $x
$x->bceil(); # return integer greater or equal than $x

# The following do not modify their arguments:

# greatest common divisor (no OO style)
my $gcd = Math::BigInt::bgcd(@values);
```

```
# lowest common multiplicator (no OO style)
my $lcm = Math::BigInt::blcm(@values);

$x->length();      # return number of digits in number
($xl,$f) = $x->length(); # length of number and length of fraction part,
    # latter is always 0 digits long for BigInts

$x->exponent();    # return exponent as BigInt
$x->mantissa();    # return (signed) mantissa as BigInt
$x->parts();       # return (mantissa,exponent) as BigInt
$x->copy();        # make a true copy of $x (unlike $y = $x;)
$x->as_int();      # return as BigInt (in BigInt: same as copy())
$x->numify();      # return as scalar (might overflow!)

# conversation to string (do not modify their argument)
$x->bstr();        # normalized string (e.g. '3')
$x->bsstr();       # norm. string in scientific notation (e.g. '3E0')
$x->as_hex();      # as signed hexadecimal string with prefixed 0x
$x->as_bin();      # as signed binary string with prefixed 0b

# precision and accuracy (see section about rounding for more)
$x->precision();   # return P of $x (or global, if P of $x undef)
$x->precision($n); # set P of $x to $n
$x->accuracy();    # return A of $x (or global, if A of $x undef)
$x->accuracy($n);  # set A $x to $n

# Global methods
Math::BigInt->precision(); # get/set global P for all BigInt objects
Math::BigInt->accuracy();  # get/set global A for all BigInt objects
Math::BigInt->round_mode(); # get/set global round mode, one of
    # 'even', 'odd', '+inf', '-inf', 'zero' or 'trunc'
Math::BigInt->config();    # return hash containing configuration
```

## DESCRIPTION

All operators (including basic math operations) are overloaded if you declare your big integers as

```
$i = new Math::BigInt '123_456_789_123_456_789';
```

Operations with overloaded operators preserve the arguments which is exactly what you expect.

### Input

Input values to these routines may be any string, that looks like a number and results in an integer, including hexadecimal and binary numbers.

Scalars holding numbers may also be passed, but note that non-integer numbers may already have lost precision due to the conversation to float. Quote your input if you want BigInt to see all the digits:

```
$x = Math::BigInt->new(12345678890123456789); # bad
$x = Math::BigInt->new('12345678901234567890'); # good
```

You can include one underscore between any two digits.

This means integer values like 1.01E2 or even 1000E-2 are also accepted. Non-integer values result in NaN.

Currently, `Math::BigInt::new()` defaults to 0, while `Math::BigInt::new("")` results in 'NaN'. This might change in the future, so use always the following explicit forms to get a zero or NaN:

```
$zero = Math::BigInt->bzero();
$nan = Math::BigInt->bnan();
```

`bnorm()` on a `BigInt` object is now effectively a no-op, since the numbers are always stored in normalized form. If passed a string, creates a `BigInt` object from the input.

#### Output

Output values are `BigInt` objects (normalized), except for the methods which return a string (see *SYNOPSIS*).

Some routines (`is_odd()`, `is_even()`, `is_zero()`, `is_one()`, `is_nan()`, etc.) return true or false, while others (`bcmp()`, `bacmp()`) return either undef (if NaN is involved), <0, 0 or >0 and are suited for sort.

## METHODS

Each of the methods below (except `config()`, `accuracy()` and `precision()`) accepts three additional parameters. These arguments `$A`, `$P` and `$R` are *accuracy*, *precision* and *round\_mode*. Please see the section about *ACCURACY* and *PRECISION* for more information.

### config

```
use Data::Dumper;

print Dumper ( Math::BigInt->config() );
print Math::BigInt->config()->{lib}, "\n";
```

Returns a hash containing the configuration, e.g. the version number, lib loaded etc. The following hash keys are currently filled in with the appropriate information.

key	Description
Example	=====
lib	Name of the low-level math library
Math::BigInt::Calc	
lib_version	Version of low-level math library (see 'lib')
0.30	
class	The class name of <code>config()</code> you just called
Math::BigInt	
upgrade	To which class math operations might be upgraded
Math::BigFloat	
downgrade	To which class math operations might be downgraded
undef	
precision	Global precision
undef	
accuracy	Global accuracy
undef	
round_mode	Global round mode
even	
version	version number of the class you used
1.61	
div_scale	Fallback accuracy for div
40	
trap_nan	If true, traps creation of NaN via <code>croak()</code>
1	
trap_inf	If true, traps creation of +inf/-inf via <code>croak()</code>

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The following values can be set by passing `config()` a reference to a hash:

```
trap_inf trap_nan
upgrade downgrade precision accuracy round_mode div_scale
```

Example:

```
$new_cfg = Math::BigInt->config( { trap_inf => 1, precision => 5 } );
```

## accuracy

```
$x->accuracy(5); # local for $x
CLASS->accuracy(5); # global for all members of CLASS
# Note: This also applies to new()!
```

```
$A = $x->accuracy(); # read out accuracy that affects $x
$A = CLASS->accuracy(); # read out global accuracy
```

Set or get the global or local accuracy, aka how many significant digits the results have. If you set a global accuracy, then this also applies to `new()`!

Warning! The accuracy *sticks*, e.g. once you created a number under the influence of `CLASS->accuracy($A)`, all results from math operations with that number will also be rounded.

In most cases, you should probably round the results explicitly using one of `round()`, `bround()` or `bround()` or by passing the desired accuracy to the math operation as additional parameter:

```
my $x = Math::BigInt->new(30000);
my $y = Math::BigInt->new(7);
print scalar $x->copy()->bdiv($y, 2); # print 4300
print scalar $x->copy()->bdiv($y)->bround(2); # print 4300
```

Please see the section about *ACCURACY AND PRECISION* for further details.

Value must be greater than zero. Pass an undef value to disable it:

```
$x->accuracy(undef);
Math::BigInt->accuracy(undef);
```

Returns the current accuracy. For `$x->accuracy()` it will return either the local accuracy, or if not defined, the global. This means the return value represents the accuracy that will be in effect for `$x`:

```
$y = Math::BigInt->new(1234567); # unrounded
print Math::BigInt->accuracy(4), "\n"; # set 4, print 4
$x = Math::BigInt->new(123456); # $x will be automatically rounded!
print "$x $y\n"; # '123500 1234567'
print $x->accuracy(), "\n"; # will be 4
print $y->accuracy(), "\n"; # also 4, since global is 4
print Math::BigInt->accuracy(5), "\n"; # set to 5, print 5
print $x->accuracy(), "\n"; # still 4
print $y->accuracy(), "\n"; # 5, since global is 5
```

Note: Works also for subclasses like `Math::BigFloat`. Each class has it's own globals separated from `Math::BigInt`, but it is possible to subclass `Math::BigInt` and make the globals of the subclass aliases to the ones from `Math::BigInt`.

## precision

```
$x->precision(-2); # local for $x, round at the second digit right of the dot
$x->precision(2); # ditto, round at the second digit left of the dot
```

```
CLASS->precision(5); # Global for all members of CLASS
# This also applies to new()!
CLASS->precision(-5); # ditto
```

```
$P = CLASS->precision(); # read out global precision
$P = $x->precision(); # read out precision that affects $x
```

Note: You probably want to use *accuracy()* instead. With *accuracy* you set the number of digits each result should have, with *precision* you set the place where to round!

*precision()* sets or gets the global or local precision, aka at which digit before or after the dot to round all results. A set global precision also applies to all newly created numbers!

In *Math::BigInt*, passing a negative number precision has no effect since no numbers have digits after the dot. In *Math::BigFloat*, it will round all results to P digits after the dot.

Please see the section about *ACCURACY AND PRECISION* for further details.

Pass an undef value to disable it:

```
$x->precision(undef);
Math::BigInt->precision(undef);
```

Returns the current precision. For *\$x->precision()* it will return either the local precision of *\$x*, or if not defined, the global. This means the return value represents the precision that will be in effect for *\$x*:

```
$y = Math::BigInt->new(1234567); # unrounded
print Math::BigInt->precision(4), "\n"; # set 4, print 4
$x = Math::BigInt->new(123456); # will be automatically rounded
print $x; # print "120000"!
```

Note: Works also for subclasses like *Math::BigFloat*. Each class has its own globals separated from *Math::BigInt*, but it is possible to subclass *Math::BigInt* and make the globals of the subclass aliases to the ones from *Math::BigInt*.

## brsft

```
$x->brsft($y,$n);
```

Shifts *\$x* right by *\$y* in base *\$n*. Default is base 2, used are usually 10 and 2, but others work, too.

Right shifting usually amounts to dividing *\$x* by *\$n \*\* \$y* and truncating the result:

```
$x = Math::BigInt->new(10);
$x->brsft(1); # same as $x >> 1: 5
$x = Math::BigInt->new(1234);
$x->brsft(2,10); # result 12
```

There is one exception, and that is base 2 with negative *\$x*:

```
$x = Math::BigInt->new(-5);
print $x->brsft(1);
```

This will print -3, not -2 (as it would if you divide -5 by 2 and truncate the result).

**new**

```
$x = Math::BigInt->new($str,$A,$P,$R);
```

Creates a new BigInt object from a scalar or another BigInt object. The input is accepted as decimal, hex (with leading '0x') or binary (with leading '0b').

See *Input* for more info on accepted input formats.

**bnan**

```
$x = Math::BigInt->bnan();
```

Creates a new BigInt object representing NaN (Not A Number). If used on an object, it will set it to NaN:

```
$x->bnan();
```

**bzero**

```
$x = Math::BigInt->bzero();
```

Creates a new BigInt object representing zero. If used on an object, it will set it to zero:

```
$x->bzero();
```

**binf**

```
$x = Math::BigInt->binf($sign);
```

Creates a new BigInt object representing infinity. The optional argument is either '-' or '+', indicating whether you want infinity or minus infinity. If used on an object, it will set it to infinity:

```
$x->binf();  
$x->binf('-');
```

**bone**

```
$x = Math::BigInt->binf($sign);
```

Creates a new BigInt object representing one. The optional argument is either '-' or '+', indicating whether you want one or minus one. If used on an object, it will set it to one:

```
$x->bone();    # +1  
$x->bone('-'); # -1
```

**is\_one()/is\_zero()/is\_nan()/is\_inf()**

```
$x->is_zero();    # true if arg is +0  
$x->is_nan();     # true if arg is NaN  
$x->is_one();     # true if arg is +1  
$x->is_one('-');  # true if arg is -1  
$x->is_inf();     # true if +inf  
$x->is_inf('-');  # true if -inf (sign is default '+')
```

These methods all test the BigInt for being one specific value and return true or false depending on

the input. These are faster than doing something like:

```
if ($x == 0)
```

### **is\_pos()/is\_neg()**

```
$x->is_pos(); # true if > 0
$x->is_neg(); # true if < 0
```

The methods return true if the argument is positive or negative, respectively. NaN is neither positive nor negative, while +inf counts as positive, and -inf is negative. A zero is neither positive nor negative.

These methods are only testing the sign, and not the value.

is\_positive() and is\_negative() are aliases to is\_pos() and is\_neg(), respectively. is\_positive() and is\_negative() were introduced in v1.36, while is\_pos() and is\_neg() were only introduced in v1.68.

### **is\_odd()/is\_even()/is\_int()**

```
$x->is_odd(); # true if odd, false for even
$x->is_even(); # true if even, false for odd
$x->is_int(); # true if $x is an integer
```

The return true when the argument satisfies the condition. NaN, +inf, -inf are not integers and are neither odd nor even.

In BigInt, all numbers except NaN, +inf and -inf are integers.

### **bcmp**

```
$x->bcmp($y);
```

Compares \$x with \$y and takes the sign into account. Returns -1, 0, 1 or undef.

### **bacmp**

```
$x->bacmp($y);
```

Compares \$x with \$y while ignoring their sign. Returns -1, 0, 1 or undef.

### **sign**

```
$x->sign();
```

Return the sign, of \$x, meaning either +, -, -inf, +inf or NaN.

If you want \$x to have a certain sign, use one of the following methods:

```
$x->babs(); # '+'
$x->babs()->bneg(); # '-'
$x->bnan(); # 'NaN'
$x->binf(); # '+inf'
$x->binf('-'); # '-inf'
```

### **digit**

```
$x->digit($n); # return the nth digit, counting from right
```

If \$n is negative, returns the digit counting from left.



**bneg**

```
$x->bneg();
```

Negate the number, e.g. change the sign between '+' and '-', or between '+inf' and '-inf', respectively. Does nothing for NaN or zero.

**babs**

```
$x->babs();
```

Set the number to it's absolute value, e.g. change the sign from '-' to '+' and from '-inf' to '+inf', respectively. Does nothing for NaN or positive numbers.

**bnorm**

```
$x->bnorm();    # normalize (no-op)
```

**bnot**

```
$x->bnot();
```

Two's complement (bit wise not). This is equivalent to

```
$x->binc()->bneg();
```

but faster.

**binc**

```
$x->binc();    # increment x by 1
```

**bdec**

```
$x->bdec();    # decrement x by 1
```

**badd**

```
$x->badd($y);  # addition (add $y to $x)
```

**bsub**

```
$x->bsub($y);  # subtraction (subtract $y from $x)
```

**bmul**

```
$x->bmul($y);  # multiplication (multiply $x by $y)
```

**bdiv**

```
$x->bdiv($y);  # divide, set $x to quotient  
               # return (quo,rem) or quo if scalar
```

**bmod**

```
$x->bmod($y);  # modulus (x % y)
```

**bmodinv**

```
num->bmodinv($mod);  # modular inverse
```

Returns the inverse of \$num in the given modulus \$mod. 'NaN' is returned unless \$num is relatively prime to \$mod, i.e. unless `bgcd($num, $mod) == 1`.

### **bmodpow**

```
$num->bmodpow($exp,$mod); # modular exponentiation
    # ($num**$exp % $mod)
```

Returns the value of \$num taken to the power \$exp in the modulus \$mod using binary exponentiation. `bmodpow` is far superior to writing

```
$num ** $exp % $mod
```

because it is much faster - it reduces internal variables into the modulus whenever possible, so it operates on smaller numbers.

`bmodpow` also supports negative exponents.

```
bmodpow($num, -1, $mod)
```

is exactly equivalent to

```
bmodinv($num, $mod)
```

### **bpow**

```
$x->bpow($y); # power of arguments (x ** y)
```

### **blsft**

```
$x->blsft($y); # left shift
$x->blsft($y,$n); # left shift, in base $n (like 10)
```

### **brsft**

```
$x->brsft($y); # right shift
$x->brsft($y,$n); # right shift, in base $n (like 10)
```

### **band**

```
$x->band($y); # bitwise and
```

### **bior**

```
$x->bior($y); # bitwise inclusive or
```

### **bxor**

```
$x->bxor($y); # bitwise exclusive or
```

### **bnot**

```
$x->bnot(); # bitwise not (two's complement)
```

### **bsqrt**

```
$x->bsqrt(); # calculate square-root
```

**bfac**

```
$x->bfac();    # factorial of $x (1*2*3*4*..$x)
```

**round**

```
$x->round($A,$P,$round_mode);
```

Round \$x to accuracy \$A or precision \$P using the round mode \$round\_mode.

**bround**

```
$x->bround($N);          # accuracy: preserve $N digits
```

**bfround**

```
$x->bfround($N);         # round to $Nth digit, no-op for BigInts
```

**bfloor**

```
$x->bfloor();
```

Set \$x to the integer less or equal than \$x. This is a no-op in BigInt, but does change \$x in BigFloat.

**bceil**

```
$x->bceil();
```

Set \$x to the integer greater or equal than \$x. This is a no-op in BigInt, but does change \$x in BigFloat.

**bgcd**

```
bgcd(@values);  # greatest common divisor (no OO style)
```

**blcm**

```
blcm(@values);  # lowest common multiplier (no OO style)
```

head2 length

```
$x->length();  
($xl,$fl) = $x->length();
```

Returns the number of digits in the decimal representation of the number. In list context, returns the length of the integer and fraction part. For BigInt's, the length of the fraction part will always be 0.

**exponent**

```
$x->exponent();
```

Return the exponent of \$x as BigInt.

**mantissa**

```
$x->mantissa();
```

Return the signed mantissa of \$x as BigInt.

**parts**

```
$x->parts(); # return (mantissa,exponent) as BigInt
```

**copy**

```
$x->copy(); # make a true copy of $x (unlike $y = $x;)
```

**as\_int**

```
$x->as_int();
```

Returns \$x as a BigInt (truncated towards zero). In BigInt this is the same as `copy()`.

`as_number()` is an alias to this method. `as_number` was introduced in v1.22, while `as_int()` was only introduced in v1.68.

**bstr**

```
$x->bstr();
```

Returns a normalized string representation of \$x.

**bsstr**

```
$x->bsstr(); # normalized string in scientific notation
```

**as\_hex**

```
$x->as_hex(); # as signed hexadecimal string with prefixed 0x
```

**as\_bin**

```
$x->as_bin(); # as signed binary string with prefixed 0b
```

## ACCURACY and PRECISION

Since version v1.33, Math::BigInt and Math::BigFloat have full support for accuracy and precision based rounding, both automatically after every operation, as well as manually.

This section describes the accuracy/precision handling in Math::Big\* as it used to be and as it is now, complete with an explanation of all terms and abbreviations.

Not yet implemented things (but with correct description) are marked with '!', things that need to be answered are marked with '?'.

In the next paragraph follows a short description of terms used here (because these may differ from terms used by others people or documentation).

During the rest of this document, the shortcuts A (for accuracy), P (for precision), F (fallback) and R (rounding mode) will be used.

### Precision P

A fixed number of digits before (positive) or after (negative) the decimal point. For example, 123.45 has a precision of -2. 0 means an integer like 123 (or 120). A precision of 2 means two digits to the left of the decimal point are zero, so 123 with P = 1 becomes 120. Note that numbers with zeros before the decimal point may have different precisions, because 1200 can have p = 0, 1 or 2 (depending on what the initial value was). It could also have p < 0, when the digits after the decimal point are zero.

The string output (of floating point numbers) will be padded with zeros:

Initial value	P	A	Result	String
1234.01	-3	1000		1000
1234	-2	1200		1200
1234.5	-1	1230		1230
1234.001	1	1234		1234.0
1234.01	0	1234		1234
1234.01	2	1234.01	1234.01	
1234.01	5	1234.01	1234.01000	

For BigInts, no padding occurs.

## Accuracy A

Number of significant digits. Leading zeros are not counted. A number may have an accuracy greater than the non-zero digits when there are zeros in it or trailing zeros. For example, 123.456 has A of 6, 10203 has 5, 123.0506 has 7, 123.450000 has 8 and 0.000123 has 3.

The string output (of floating point numbers) will be padded with zeros:

Initial value	P	A	Result	String
1234.01	3	1230	1230	
1234.01	6	1234.01	1234.01	
1234.1	8	1234.1	1234.1000	

For BigInts, no padding occurs.

## Fallback F

When both A and P are undefined, this is used as a fallback accuracy when dividing numbers.

## Rounding mode R

When rounding a number, different 'styles' or 'kinds' of rounding are possible. (Note that random rounding, as in Math::Round, is not implemented.)

'trunc'

truncation invariably removes all digits following the rounding place, replacing them with zeros. Thus, 987.65 rounded to tens (P=1) becomes 980, and rounded to the fourth sigdig becomes 987.6 (A=4). 123.456 rounded to the second place after the decimal point (P=-2) becomes 123.46.

All other implemented styles of rounding attempt to round to the "nearest digit." If the digit D immediately to the right of the rounding place (skipping the decimal point) is greater than 5, the number is incremented at the rounding place (possibly causing a cascade of incrementation): e.g. when rounding to units, 0.9 rounds to 1, and -19.9 rounds to -20. If  $D < 5$ , the number is similarly truncated at the rounding place: e.g. when rounding to units, 0.4 rounds to 0, and -19.4 rounds to -19.

However the results of other styles of rounding differ if the digit immediately to the right of the rounding place (skipping the decimal point) is 5 and if there are no digits, or no digits other than 0, after that 5. In such cases:

'even'

rounds the digit at the rounding place to 0, 2, 4, 6, or 8 if it is not already. E.g., when rounding to the first sigdig, 0.45 becomes 0.4, -0.55 becomes -0.6, but 0.4501 becomes 0.5.

'odd'

rounds the digit at the rounding place to 1, 3, 5, 7, or 9 if it is not already. E.g., when rounding to

the first sigdig, 0.45 becomes 0.5, -0.55 becomes -0.5, but 0.5501 becomes 0.6.

'+inf'

round to plus infinity, i.e. always round up. E.g., when rounding to the first sigdig, 0.45 becomes 0.5, -0.55 becomes -0.5, and 0.4501 also becomes 0.5.

'-inf'

round to minus infinity, i.e. always round down. E.g., when rounding to the first sigdig, 0.45 becomes 0.4, -0.55 becomes -0.6, but 0.4501 becomes 0.5.

'zero'

round to zero, i.e. positive numbers down, negative ones up. E.g., when rounding to the first sigdig, 0.45 becomes 0.4, -0.55 becomes -0.5, but 0.4501 becomes 0.5.

The handling of A & P in MBI/MBF (the old core code shipped with Perl versions <= 5.7.2) is like this:

#### Precision

- \* `ffround($p)` is able to round to \$p number of digits after the decimal point
- \* otherwise P is unused

#### Accuracy (significant digits)

- \* `fround($a)` rounds to \$a significant digits
- \* only `fdiv()` and `fsqrt()` take A as (optional) parameter
  - + other operations simply create the same number (`fneg` etc), or more (fmul)
  - of digits
  - + rounding/truncating is only done when explicitly calling one of `fround` or `ffround`, and never for `BigInt` (not implemented)
- \* `fsqrt()` simply hands its accuracy argument over to `fdiv`.
- \* the documentation and the comment in the code indicate two different ways
  - on how `fdiv()` determines the maximum number of digits it should calculate,
  - and the actual code does yet another thing

```
POD:
    max($Math::BigFloat::div_scale,length(dividend)+length(divisor))
Comment:
    result has at most max(scale, length(dividend), length(divisor))
digits
Actual code:
    scale = max(scale, length(dividend)-1,length(divisor)-1);
    scale += length(divisor) - length(dividend);
    So for lx = 3, ly = 9, scale = 10, scale will actually be 16
(10+9-3).
```

Actually, the 'difference' added to the scale is calculated from the number of "significant digits" in dividend and divisor, which is derived by looking at the length of the mantissa. Which is wrong, since it includes the + sign (oops) and actually gets 2 for '+100' and 4 for '+101'.

Oops

again. Thus 124/3 with `div_scale=1` will get you '41.3' based on the strange

assumption that 124 has 3 significant digits, while 120/7 will get you '17', not '17.1' since 120 is thought to have 2 significant digits. The rounding after the division then uses the remainder and \$y to determine whether it must round up or down.

? I have no idea which is the right way. That's why I used a slightly more

? simple scheme and tweaked the few failing testcases to match it.

This is how it works now:

### Setting/Accessing

- \* You can set the A global via `C<< Math::BigInt->accuracy() >>` or `C<< Math::BigFloat->accuracy() >>` or whatever class you are using.
- \* You can also set P globally by using `C<< Math::SomeClass->precision() >>` likewise.
- \* Globals are classwide, and not inherited by subclasses.
- \* to undefine A, use `C<< Math::SomeClass->accuracy(undef); >>`
- \* to undefine P, use `C<< Math::SomeClass->precision(undef); >>`
- \* Setting `C<< Math::SomeClass->accuracy() >>` clears automatically `C<< Math::SomeClass->precision() >>`, and vice versa.
- \* To be valid, A must be  $> 0$ , P can have any value.
- \* If P is negative, this means round to the P'th place to the right of the decimal point; positive values mean to the left of the decimal point.
- \* P of 0 means round to integer.
- \* to find out the current global A, use `C<< Math::SomeClass->accuracy() >>`
- \* to find out the current global P, use `C<< Math::SomeClass->precision() >>`
- \* use `C<< $x->accuracy() >>` respective `C<< $x->precision() >>` for the local setting of `C<< $x >>`.
- \* Please note that `C<< $x->accuracy() >>` respective `C<< $x->precision() >>` return eventually defined global A or P, when `C<< $x >>`'s A or P is not set.

### Creating numbers

- \* When you create a number, you can give it's desired A or P via:  
`$x = Math::BigInt->new($number,$A,$P);`
- \* Only one of A or P can be defined, otherwise the result is NaN
- \* If no A or P is give (`$x = Math::BigInt->new($number)` form), then the globals (if set) will be used. Thus changing the global defaults later on will not change the A or P of previously created numbers (i.e., A and P of `$x` will be what was in effect when `$x` was created)
- \* If given undef for A and P, B<no> rounding will occur, and the globals will

B<not> be used. This is used by subclasses to create numbers without suffering rounding in the parent. Thus a subclass is able to have it's own

```
globals enforced upon creation of a number by using
C<< $x = Math::BigInt->new($number,undef,undef) >>:
```

```
use Math::BigInt::SomeSubclass;
use Math::BigInt;
```

```
Math::BigInt->accuracy(2);
Math::BigInt::SomeSubClass->accuracy(3);
$x = Math::BigInt::SomeSubClass->new(1234);
```

\$x is now 1230, and not 1200. A subclass might choose to implement this otherwise, e.g. falling back to the parent's A and P.

## Usage

- \* If A or P are enabled/defined, they are used to round the result of each operation according to the rules below
- \* Negative P is ignored in Math::BigInt, since BigInts never have digits after the decimal point
- \* Math::BigFloat uses Math::BigInt internally, but setting A or P inside Math::BigInt as globals does not tamper with the parts of a BigFloat. A flag is used to mark all Math::BigFloat numbers as 'never round'.

## Precedence

- \* It only makes sense that a number has only one of A or P at a time. If you set either A or P on one object, or globally, the other one will be automatically cleared.
- \* If two objects are involved in an operation, and one of them has A in effect, and the other P, this results in an error (NaN).
- \* A takes precedence over P (Hint: A comes before P). If neither of them is defined, nothing is used, i.e. the result will have as many digits as it can (with an exception for fdiv/fsqrt) and will not be rounded.
- \* There is another setting for fdiv() (and thus for fsqrt()). If neither of A or P is defined, fdiv() will use a fallback (F) of \$div\_scale digits. If either the dividend's or the divisor's mantissa has more digits than the value of F, the higher value will be used instead of F. This is to limit the digits (A) of the result (just consider what would happen with unlimited A and P in the case of 1/3 :-)
- \* fdiv will calculate (at least) 4 more digits than required (determined by



A, P or F), and, if F is not used, round the result  
(this will still fail in the case of a result like 0.123450000000001  
with A  
or P of 5, but this can not be helped - or can it?)  
\* Thus you can have the math done by on Math::Big\* class in two modi:  
+ never round (this is the default):  
This is done by setting A and P to undef. No math operation  
will round the result, with fdiv() and fsqrt() as exceptions to  
guard  
against overflows. You must explicitly call bround(), bround()  
or  
round() (the latter with parameters).  
Note: Once you have rounded a number, the settings will 'stick' on  
it  
and 'infect' all other numbers engaged in math operations with it,  
since  
local settings have the highest precedence. So, to get  
SaferRound[tm],  
use a copy() before rounding like this:

```
$x = Math::BigFloat->new(12.34);  
$y = Math::BigFloat->new(98.76);  
$z = $x * $y;                                # 1218.6984  
print $x->copy()->fround(3);                  # 12.3 (but A is now 3!)  
$z = $x * $y;                                # still 1218.6984,
```

without  
# copy would have been  
1210!

+ round after each op:  
After each single operation (except for testing like is\_zero()),  
the  
method round() is called and the result is rounded appropriately.  
By  
setting proper values for A and P, you can have all-the-same-A or  
all-the-same-P modes. For example, Math::Currency might set A to  
undef,  
and P to -2, globally.

?Maybe an extra option that forbids local A & P settings would be in  
order,  
?so that intermediate rounding does not 'poison' further math?

### Overriding globals

\* you will be able to give A, P and R as an argument to all the  
calculation  
routines; the second parameter is A, the third one is P, and the  
fourth is  
R (shift right by one for binary operations like badd). P is used  
only if  
the first parameter (A) is undefined. These three parameters  
override the  
globals in the order detailed as follows, i.e. the first defined  
value  
wins:

```
(local: per object, global: global default, parameter: argument to
sub)
    + parameter A
    + parameter P
    + local A (if defined on both of the operands: smaller one is
taken)
    + local P (if defined on both of the operands: bigger one is
taken)
    + global A
    + global P
    + global F
    * fsqrt() will hand its arguments to fdiv(), as it used to, only now
for two
    arguments (A and P) instead of one
```

### Local settings

- \* You can set A or P locally by using `C<< $x->accuracy() >>` or `C<< $x->precision() >>` and thus force different A and P for different objects/numbers.
- \* Setting A or P this way immediately rounds \$x to the new value.
- \* `C<< $x->accuracy() >>` clears `C<< $x->precision() >>`, and vice versa.

### Rounding

- \* the rounding routines will use the respective global or local settings.  
`fround()/bround()` is for accuracy rounding, while `ffround()/bfround()` is for precision
- \* the two rounding functions take as the second parameter one of the following rounding modes (R):  
'even', 'odd', '+inf', '-inf', 'zero', 'trunc'
- \* you can set/get the global R by using `C<< Math::SomeClass->round_mode() >>` or by setting `C<< $Math::SomeClass::round_mode >>`
- \* after each operation, `C<< $result->round() >>` is called, and the result may eventually be rounded (that is, if A or P were set either locally, globally or as parameter to the operation)
- \* to manually round a number, call `C<< $x->round($A,$P,$round_mode); >>`  
this will round the number by using the appropriate rounding function and then normalize it.
- \* rounding modifies the local settings of the number:

```
$x = Math::BigFloat->new(123.456);
$x->accuracy(5);
$x->bround(4);
```

Here 4 takes precedence over 5, so 123.5 is the result and `$x->accuracy()` will be 4 from now on.

### Default values

```
* R: 'even'
* F: 40
* A: undef
* P: undef
```

#### Remarks

```
* The defaults are set up so that the new code gives the same results
as
the old code (except in a few cases on fdiv):
+ Both A and P are undefined and thus will not be used for rounding
  after each operation.
+ round() is thus a no-op, unless given extra parameters A and P
```

## Infinity and Not a Number

While BigInt has extensive handling of inf and NaN, certain quirks remain.

#### oct()/hex()

These perl routines currently (as of Perl v.5.8.6) cannot handle passed inf.

```
te@linux:~> perl -wle 'print 2 ** 3333'
inf
te@linux:~> perl -wle 'print 2 ** 3333 == 2 ** 3333'
1
te@linux:~> perl -wle 'print oct(2 ** 3333)'
0
te@linux:~> perl -wle 'print hex(2 ** 3333)'
Illegal hexadecimal digit 'i' ignored at -e line 1.
0
```

The same problems occur if you pass them Math::BigInt->binf() objects. Since overloading these routines is not possible, this cannot be fixed from BigInt.

#### ==, !=, <, >, <=, >= with NaNs

BigInt's bcmp() routine currently returns undef to signal that a NaN was involved in a comparison. However, the overload code turns that into either 1 or "" and thus operations like NaN != NaN might return wrong values.

#### log(-inf)

log(-inf) is highly weird. Since  $\log(-x) = \pi i + \log(x)$ , then  $\log(-\text{inf}) = \pi i + \text{inf}$ . However, since the imaginary part is finite, the real infinity "overshadows" it, so the number might as well just be infinity. However, the result is a complex number, and since BigInt/BigFloat can only have real numbers as results, the result is NaN.

#### exp(), cos(), sin(), atan2()

These all might have problems handling infinity right.

## INTERNALS

The actual numbers are stored as unsigned big integers (with separate sign).

You should neither care about nor depend on the internal representation; it might change without notice. Use **ONLY** method calls like `$x->sign()`; instead relying on the internal representation.

## MATH LIBRARY

Math with the numbers is done (by default) by a module called Math::BigInt::Calc. This is equivalent to saying:

```
use Math::BigInt lib => 'Calc';
```

You can change this by using:

```
use Math::BigInt lib => 'BitVect';
```

The following would first try to find `Math::BigInt::Foo`, then `Math::BigInt::Bar`, and when this also fails, revert to `Math::BigInt::Calc`:

```
use Math::BigInt lib => 'Foo,Math::BigInt::Bar';
```

Since `Math::BigInt::GMP` is in almost all cases faster than `Calc` (especially in math involving really big numbers, where it is **much** faster), and there is no penalty if `Math::BigInt::GMP` is not installed, it is a good idea to always use the following:

```
use Math::BigInt lib => 'GMP';
```

Different low-level libraries use different formats to store the numbers. You should **NOT** depend on the number having a specific format internally.

See the respective math library module documentation for further details.

## SIGN

The sign is either '+', '-', 'NaN', '+inf' or '-inf'.

A sign of 'NaN' is used to represent the result when input arguments are not numbers or as a result of 0/0. '+inf' and '-inf' represent plus respectively minus infinity. You will get '+inf' when dividing a positive number by 0, and '-inf' when dividing any negative number by 0.

## mantissa(), exponent() and parts()

`mantissa()` and `exponent()` return the said parts of the `BigInt` such that:

```
$m = $x->mantissa();
$e = $x->exponent();
$y = $m * ( 10 ** $e );
print "ok\n" if $x == $y;
```

`($m,$e) = $x->parts()` is just a shortcut that gives you both of them in one go. Both the returned mantissa and exponent have a sign.

Currently, for `BigInts` `$e` is always 0, except for NaN, +inf and -inf, where it is NaN; and for `$x == 0`, where it is 1 (to be compatible with `Math::BigFloat`'s internal representation of a zero as 0E1).

`$m` is currently just a copy of the original number. The relation between `$e` and `$m` will stay always the same, though their real values might change.

## EXAMPLES

```
use Math::BigInt;
```

```
sub bint { Math::BigInt->new(shift); }
```

```
$x = Math::BigInt->bstr("1234")      # string "1234"
$x = "$x";                          # same as bstr()
$x = Math::BigInt->bneg("1234");     # BigInt "-1234"
$x = Math::BigInt->babs("-12345");    # BigInt "12345"
$x = Math::BigInt->bnorm("-0 00");   # BigInt "0"
```

```
$x = bint(1) + bint(2);          # BigInt "3"
$x = bint(1) + "2";              # ditto (auto-BigIntify of "2")
$x = bint(1);                    # BigInt "1"
$x = $x + 5 / 2;                 # BigInt "3"
$x = $x ** 3;                    # BigInt "27"
$x *= 2;                         # BigInt "54"
$x = Math::BigInt->new(0);        # BigInt "0"
$x--;                            # BigInt "-1"
$x = Math::BigInt->badd(4,5)      # BigInt "9"
print $x->bsstr();               # 9e+0
```

#### Examples for rounding:

```
use Math::BigFloat;
use Test;

$x = Math::BigFloat->new(123.4567);
$y = Math::BigFloat->new(123.456789);
Math::BigFloat->accuracy(4); # no more A than 4

ok ($x->copy()->fround(),123.4); # even rounding
print $x->copy()->fround(),"\n"; # 123.4
Math::BigFloat->round_mode('odd'); # round to odd
print $x->copy()->fround(),"\n"; # 123.5
Math::BigFloat->accuracy(5); # no more A than 5
Math::BigFloat->round_mode('odd'); # round to odd
print $x->copy()->fround(),"\n"; # 123.46
$y = $x->copy()->fround(4)," \n"; # A = 4: 123.4
print "$y, ", $y->accuracy(),"\n"; # 123.4, 4

Math::BigFloat->accuracy(undef); # A not important now
Math::BigFloat->precision(2); # P important
print $x->copy()->bnorm(),"\n"; # 123.46
print $x->copy()->fround(),"\n"; # 123.46
```

#### Examples for converting:

```
my $x = Math::BigInt->new('0b1'. '01' x 123);
print "bin: ", $x->as_bin(), " hex: ", $x->as_hex(), " dec: ", $x, "\n";
```

## Autocreating constants

After use `Math::BigInt ':constant'` all the **integer** decimal, hexadecimal and binary constants in the given scope are converted to `Math::BigInt`. This conversion happens at compile time.

In particular,

```
perl -MMath::BigInt=:constant -e 'print 2**100, "\n"'
```

prints the integer value of `2**100`. Note that without conversion of constants the expression `2**100` will be calculated as perl scalar.

Please note that strings and floating point constants are not affected, so that

```
use Math::BigInt qw/:constant/;
```

```
$x = 1234567890123456789012345678901234567890
+ 123456789123456789;
$y = '1234567890123456789012345678901234567890'
+ '123456789123456789';
```

do not work. You need an explicit `Math::BigInt->new()` around one of the operands. You should also quote large constants to protect loss of precision:

```
use Math::BigInt;

$x = Math::BigInt->new('1234567889123456789123456789123456789');
```

Without the quotes Perl would convert the large number to a floating point constant at compile time and then hand the result to `BigInt`, which results in a truncated result or a NaN.

This also applies to integers that look like floating point constants:

```
use Math::BigInt ':constant';

print ref(123e2), "\n";
print ref(123.2e2), "\n";
```

will print nothing but newlines. Use either *bignum* or *Math::BigFloat* to get this to work.

## PERFORMANCE

Using the form `$x += $y`; etc over `$x = $x + $y` is faster, since a copy of `$x` must be made in the second case. For long numbers, the copy can eat up to 20% of the work (in the case of addition/subtraction, less for multiplication/division). If `$y` is very small compared to `$x`, the form `$x += $y` is MUCH faster than `$x = $x + $y` since making the copy of `$x` takes more time than the actual addition.

With a technique called copy-on-write, the cost of copying with overload could be minimized or even completely avoided. A test implementation of COW did show performance gains for overloaded math, but introduced a performance loss due to a constant overhead for all other operators. So `Math::BigInt` does currently not COW.

The rewritten version of this module (vs. v0.01) is slower on certain operations, like `new()`, `bstr()` and `numify()`. The reason are that it does now more work and handles much more cases. The time spent in these operations is usually gained in the other math operations so that code on the average should get (much) faster. If they don't, please contact the author.

Some operations may be slower for small numbers, but are significantly faster for big numbers. Other operations are now constant ( $O(1)$ ), like `bneg()`, `babs()` etc), instead of  $O(N)$  and thus nearly always take much less time. These optimizations were done on purpose.

If you find the `Calc` module to slow, try to install any of the replacement modules and see if they help you.

## Alternative math libraries

You can use an alternative library to drive `Math::BigInt` via:

```
use Math::BigInt lib => 'Module';
```

See *MATH LIBRARY* for more information.

For more benchmark results see <http://bloodgate.com/perl/benchmarks.html>.

## SUBCLASSING

### Subclassing Math::BigInt

The basic design of Math::BigInt allows simple subclasses with very little work, as long as a few simple rules are followed:

- The public API must remain consistent, i.e. if a sub-class is overloading addition, the sub-class must use the same name, in this case `badd()`. The reason for this is that Math::BigInt is optimized to call the object methods directly.
- The private object hash keys like `$x->{sign}` may not be changed, but additional keys can be added, like `$x->{_custom}`.
- Accessor functions are available for all existing object hash keys and should be used instead of directly accessing the internal hash keys. The reason for this is that Math::BigInt itself has a pluggable interface which permits it to support different storage methods.

More complex sub-classes may have to replicate more of the logic internal of Math::BigInt if they need to change more basic behaviors. A subclass that needs to merely change the output only needs to overload `bstr()`.

All other object methods and overloaded functions can be directly inherited from the parent class.

At the very minimum, any subclass will need to provide it's own `new()` and can store additional hash keys in the object. There are also some package globals that must be defined, e.g.:

```
# Globals
$accuracy = undef;
$precision = -2;      # round to 2 decimal places
$round_mode = 'even';
$div_scale = 40;
```

Additionally, you might want to provide the following two globals to allow auto-upgrading and auto-downgrading to work correctly:

```
$upgrade = undef;
$downgrade = undef;
```

This allows Math::BigInt to correctly retrieve package globals from the subclass, like `$SubClass::precision`. See `t/Math/BigInt/Subclass.pm` or `t/Math/BigFloat/SubClass.pm` completely functional subclass examples.

Don't forget to

```
use overload;
```

in your subclass to automatically inherit the overloading from the parent. If you like, you can change part of the overloading, look at Math::String for an example.

## UPGRADING

When used like this:

```
use Math::BigInt upgrade => 'Foo::Bar';
```

certain operations will 'upgrade' their calculation and thus the result to the class `Foo::Bar`. Usually this is used in conjunction with Math::BigFloat:

```
use Math::BigInt upgrade => 'Math::BigFloat';
```

As a shortcut, you can use the module `bignum`:

```
use bignum;
```

Also good for oneliners:

```
perl -Mbignum -le 'print 2 ** 255'
```

This makes it possible to mix arguments of different classes (as in  $2.5 + 2$ ) as well as preserve accuracy (as in `sqrt(3)`).

Beware: This feature is not fully implemented yet.

## Auto-upgrade

The following methods upgrade themselves unconditionally; that is if upgrade is in effect, they will always hand up their work:

`bsqrt()`

`div()`

`blog()`

Beware: This list is not complete.

All other methods upgrade themselves only when one (or all) of their arguments are of the class mentioned in `$upgrade` (This might change in later versions to a more sophisticated scheme):

## BUGS

`broot()` does not work

The `broot()` function in `BigInt` may only work for small values. This will be fixed in a later version.

Out of Memory!

Under Perl prior to 5.6.0 having an `use Math::BigInt ':constant';` and `eval()` in your code will crash with "Out of memory". This is probably an overload/exporter bug. You can workaround by not having `eval()` and `:constant` at the same time or upgrade your Perl to a newer version.

Fails to load Calc on Perl prior 5.6.0

Since `eval('use ...')` can not be used in conjunction with `:constant`, `BigInt` will fall back to `eval { require ... }` when loading the math lib on Perls prior to 5.6.0. This simply replaces `::` with `/` and thus might fail on filesystems using a different separator.

## CAVEATS

Some things might not work as you expect them. Below is documented what is known to be troublesome:

`bstr()`, `bsstr()` and `'cmp'`

Both `bstr()` and `bsstr()` as well as automated stringify via overload now drop the leading `+`. The old code would return `'+3'`, the new returns `'3'`. This is to be consistent with Perl and to make `cmp` (especially with overloading) to work as you expect. It also solves problems with `Test.pm`, because it's `ok()` uses `'eq'` internally.

Mark Biggar said, when asked about to drop the `+` altogether, or make only `cmp` work:

I agree (with the first alternative), don't add the `+` on positive numbers. It's not as important anymore with the new internal form for numbers. It made doing things like `abs` and `neg` easier, but those have to be done differently now anyway.



So, the following examples will now work all as expected:

```
use Test;
    BEGIN { plan tests => 1 }
use Math::BigInt;

my $x = new Math::BigInt 3*3;
my $y = new Math::BigInt 3*3;

ok ($x,3*3);
print "$x eq 9" if $x eq $y;
print "$x eq 9" if $x eq '9';
print "$x eq 9" if $x eq 3*3;
```

Additionally, the following still works:

```
print "$x == 9" if $x == $y;
print "$x == 9" if $x == 9;
print "$x == 9" if $x == 3*3;
```

There is now a `bsstr()` method to get the string in scientific notation aka `1e+2` instead of `100`. Be advised that overloaded `'eq'` always uses `bstr()` for comparison, but Perl will represent some numbers as `100` and others as `1e+308`. If in doubt, convert both arguments to `Math::BigInt` before comparing them as strings:

```
use Test;
    BEGIN { plan tests => 3 }
use Math::BigInt;

$x = Math::BigInt->new('1e56'); $y = 1e56;
ok ($x,$y);    # will fail
ok ($x->bsstr(),$y); # okay
$y = Math::BigInt->new($y);
ok ($x,$y);    # okay
```

Alternatively, simply use `<=>` for comparisons, this will get it always right. There is not yet a way to get a number automatically represented as a string that matches exactly the way Perl represents it.

See also the section about *Infinity and Not a Number* for problems in comparing NaNs.

`int()`

`int()` will return (at least for Perl v5.7.1 and up) another `BigInt`, not a Perl scalar:

```
$x = Math::BigInt->new(123);
$y = int($x);    # BigInt 123
$x = Math::BigFloat->new(123.45);
$y = int($x);    # BigInt 123
```

In all Perl versions you can use `as_number()` or `as_int` for the same effect:

```
$x = Math::BigFloat->new(123.45);
$y = $x->as_number(); # BigInt 123
$y = $x->as_int();    # ditto
```

This also works for other subclasses, like `Math::String`.

It is yet unclear whether overloaded `int()` should return a scalar or a `BigInt`.

If you want a real Perl scalar, use `numify()`:

```
$y = $x->numify(); # 123 as scalar
```

This is seldom necessary, though, because this is done automatically, like when you access an array:

```
$z = $array[$x];    # does work automatically
```

#### length

The following will probably not do what you expect:

```
$c = Math::BigInt->new(123);  
print $c->length(),"\n";    # prints 30
```

It prints both the number of digits in the number and in the fraction part since `print` calls `length()` in list context. Use something like:

```
print scalar $c->length(),"\n";    # prints 3
```

#### bdiv

The following will probably not do what you expect:

```
print $c->bdiv(10000),"\\n";
```

It prints both quotient and remainder since `print` calls `bdiv()` in list context. Also, `bdiv()` will modify `$c`, so be careful. You probably want to use

```
print $c / 10000,"\\n";  
print scalar $c->bdiv(10000),"\\n";    # or if you want to modify $c
```

instead.

The quotient is always the greatest integer less than or equal to the real-valued quotient of the two operands, and the remainder (when it is nonzero) always has the same sign as the second operand; so, for example,

```
1 / 4    => ( 0, 1)  
1 / -4   => (-1,-3)  
-3 / 4    => (-1, 1)  
-3 / -4   => ( 0,-3)  
-11 / 2   => (-5,1)  
11 / -2   => (-5,-1)
```

As a consequence, the behavior of the operator `%` agrees with the behavior of Perl's built-in `%` operator (as documented in the `perlop` manpage), and the equation

```
$x == ($x / $y) * $y + ($x % $y)
```

holds true for any `$x` and `$y`, which justifies calling the two return values of `bdiv()` the quotient and remainder. The only exception to this rule are when `$y == 0` and `$x` is negative, then the remainder will also be negative. See below under "infinity handling" for the reasoning behind this.

Perl's 'use integer;' changes the behaviour of `%` and `/` for scalars, but will not change `BigInt`'s way to do things. This is because under 'use integer' Perl will do what the underlying C thinks is right and this is different for each system. If you need `BigInt`'s behaving exactly like Perl's 'use integer', bug the author to implement it ;)

#### infinity handling

Here are some examples that explain the reasons why certain results occur while handling infinity:

The following table shows the result of the division and the remainder, so that the equation above holds true. Some "ordinary" cases are strewn in to show more clearly the reasoning:

```
A / B = C,      R so that C * B + R = A  
=====
```

```

5 / 8 = 0,      5      0 * 8 + 5 = 5
0 / 8 = 0,      0      0 * 8 + 0 = 0
0 / inf = 0,    0      0 * inf + 0 = 0
0 / -inf = 0,   0      0 * -inf + 0 = 0
5 / inf = 0,    5      0 * inf + 5 = 5
5 / -inf = 0,   5      0 * -inf + 5 = 5
-5 / inf = 0,   -5     0 * inf + -5 = -5
-5 / -inf = 0,  -5     0 * -inf + -5 = -5
      inf / 5 = inf,   0      inf * 5 + 0 = inf
      -inf / 5 = -inf, 0      -inf * 5 + 0 = -inf
      inf / -5 = -inf, 0      -inf * -5 + 0 = inf
      -inf / -5 = inf, 0      inf * -5 + 0 = -inf
5 / 5 = 1,      0      1 * 5 + 0 = 5
-5 / -5 = 1,    0      1 * -5 + 0 = -5
      inf / inf = 1,   0      1 * inf + 0 = inf
      -inf / -inf = 1, 0      1 * -inf + 0 = -inf
      inf / -inf = -1, 0      -1 * -inf + 0 = inf
      -inf / inf = -1, 0      1 * -inf + 0 = -inf
8 / 0 = inf,    8      inf * 0 + 8 = 8
      inf / 0 = inf,  inf   inf * 0 + inf = inf
      0 / 0 = NaN

```

These cases below violate the "remainder has the sign of the second of the two arguments", since they wouldn't match up otherwise.

```

A / B = C,      R so that C * B + R = A
=====
      -inf / 0 = -inf, -inf      -inf * 0 + inf = -inf
-8 / 0 = -inf,  -8      -inf * 0 + 8 = -8

```

## Modifying and =

Beware of:

```

$x = Math::BigFloat->new(5);
$y = $x;

```

It will not do what you think, e.g. making a copy of \$x. Instead it just makes a second reference to the **same** object and stores it in \$y. Thus anything that modifies \$x (except overloaded operators) will modify \$y, and vice versa. Or in other words, = is only safe if you modify your BigInts only via overloaded math. As soon as you use a method call it breaks:

```

$x->bmul(2);
print "$x, $y\n";          # prints '10, 10'

```

If you want a true copy of \$x, use:

```

$y = $x->copy();

```

You can also chain the calls like this, this will make first a copy and then multiply it by 2:

```

$y = $x->copy()->bmul(2);

```

See also the documentation for overload.pm regarding =.

## bpow

bpow() (and the rounding functions) now modifies the first argument and returns it, unlike the old code which left it alone and only returned the result. This is to be consistent with badd() etc. The first three will modify \$x, the last one won't:

```
print bpow($x,$i),"\n"; # modify $x
print $x->bpow($i),"\n"; # ditto
print $x **= $i,"\n"; # the same
print $x ** $i,"\n"; # leave $x alone
```

The form `$x **= $y` is faster than `$x = $x ** $y`; though.

### Overloading -`$x`

The following:

```
$x = -$x;
```

is slower than

```
$x->bneg();
```

since overload calls `sub($x,0,1);` instead of `neg($x)`. The first variant needs to preserve `$x` since it does not know that it later will get overwritten. This makes a copy of `$x` and takes  $O(N)$ , but `$x->bneg()` is  $O(1)$ .

### Mixing different object types

In Perl you will get a floating point value if you do one of the following:

```
$float = 5.0 + 2;
$float = 2 + 5.0;
$float = 5 / 2;
```

With overloaded math, only the first two variants will result in a BigFloat:

```
use Math::BigInt;
use Math::BigFloat;

$mbf = Math::BigFloat->new(5);
$mbi2 = Math::BigInteger->new(5);
$mbi = Math::BigInteger->new(2);

# what actually gets called:
$float = $mbf + $mbi; # $mbf->badd()
$float = $mbf / $mbi; # $mbf->bdiv()
$integer = $mbi + $mbf; # $mbi->badd()
$integer = $mbi2 / $mbi; # $mbi2->bdiv()
$integer = $mbi2 / $mbf; # $mbi2->bdiv()
```

This is because math with overloaded operators follows the first (dominating) operand, and the operation of that is called and returns thus the result. So, `Math::BigInt::bdiv()` will always return a `Math::BigInt`, regardless whether the result should be a `Math::BigFloat` or the second operand is one.

To get a `Math::BigFloat` you either need to call the operation manually, make sure the operands are already of the proper type or casted to that type via `Math::BigFloat->new()`:

```
$float = Math::BigFloat->new($mbi2) / $mbi; # = 2.5
```

Beware of simple "casting" the entire expression, this would only convert the already computed result:

```
$float = Math::BigFloat->new($mbi2 / $mbi); # = 2.0 thus wrong!
```

Beware also of the order of more complicated expressions like:

```
$integer = ($mbi2 + $mbi) / $mbf; # int / float => int
$integer = $mbi2 / Math::BigFloat->new($mbi); # ditto
```

If in doubt, break the expression into simpler terms, or cast all operands to the desired resulting type.

Scalar values are a bit different, since:

```
$float = 2 + $mbf;  
$float = $mbf + 2;
```

will both result in the proper type due to the way the overloaded math works.

This section also applies to other overloaded math packages, like Math::String.

One solution to your problem might be autoupgrading/upgrading. See the pragmas *bignum*, *bigint* and *bigrat* for an easy way to do this.

### bsqrt()

`bsqrt()` works only good if the result is a big integer, e.g. the square root of 144 is 12, but from 12 the square root is 3, regardless of rounding mode. The reason is that the result is always truncated to an integer.

If you want a better approximation of the square root, then use:

```
$x = Math::BigFloat->new(12);  
Math::BigFloat->precision(0);  
Math::BigFloat->round_mode('even');  
print $x->copy->bsqrt(),"\n"; # 4  
  
Math::BigFloat->precision(2);  
print $x->bsqrt(),"\n"; # 3.46  
print $x->bsqrt(3)," \n"; # 3.464
```

### brsft()

For negative numbers in base see also *brsft*.

## LICENSE

This program is free software; you may redistribute it and/or modify it under the same terms as Perl itself.

## SEE ALSO

*Math::BigFloat*, *Math::BigRat* and *Math::Big* as well as *Math::BigInt::BitVect*, *Math::BigInt::Pari* and *Math::BigInt::GMP*.

The pragmas *bignum*, *bigint* and *bigrat* also might be of interest because they solve the autoupgrading/downgrading issue, at least partly.

The package at <http://search.cpan.org/search?mode=module&query=Math%3A%3ABigInt> contains more documentation including a full version history, testcases, empty subclass files and benchmarks.

## AUTHORS

Original code by Mark Biggar, overloaded interface by Ilya Zakharevich. Completely rewritten by Tels <http://bloodgate.com> in late 2000, 2001 - 2004 and still at it in 2005.

Many people contributed in one or more ways to the final beast, see the file CREDITS for an (uncomplete) list. If you miss your name, please drop me a mail. Thank you!