

NAME

perlop - Perl operators and precedence

DESCRIPTION**Operator Precedence and Associativity**

Operator precedence and associativity work in Perl more or less like they do in mathematics.

Operator precedence means some operators are evaluated before others. For example, in $2 + 4 * 5$, the multiplication has higher precedence so $4 * 5$ is evaluated first yielding $2 + 20 == 22$ and not $6 * 5 == 30$.

Operator associativity defines what happens if a sequence of the same operators is used one after another: whether the evaluator will evaluate the left operations first or the right. For example, in $8 - 4 - 2$, subtraction is left associative so Perl evaluates the expression left to right. $8 - 4$ is evaluated first making the expression $4 - 2 == 2$ and not $8 - 2 == 6$.

Perl operators have the following associativity and precedence, listed from highest precedence to lowest. Operators borrowed from C keep the same precedence relationship with each other, even where C's precedence is slightly screwy. (This makes learning Perl easier for C folks.) With very few exceptions, these all operate on scalar values only, not array values.

```

left terms and list operators (leftward)
left ->
nonassoc ++ --
right **
right ! ~ \ and unary + and -
left =~ !~
left * / % x
left + - .
left << >>
nonassoc named unary operators
nonassoc < > <= >= lt gt le ge
nonassoc == != <=> eq ne cmp
left &
left | ^
left &&
left ||
nonassoc .. ...
right ?:
right = += -= *= etc.
left , =>
nonassoc list operators (rightward)
right not
left and
left or xor

```

In the following sections, these operators are covered in precedence order.

Many operators can be overloaded for objects. See *overload*.

Terms and List Operators (Leftward)

A TERM has the highest precedence in Perl. They include variables, quote and quote-like operators, any expression in parentheses, and any function whose arguments are parenthesized. Actually, there aren't really functions in this sense, just list operators and unary operators behaving as functions because you put parentheses around the arguments. These are all documented in *perlfunc*.

If any list operator (print(), etc.) or any unary operator (chdir(), etc.) is followed by a left parenthesis as

the next token, the operator and arguments within parentheses are taken to be of highest precedence, just like a normal function call.

In the absence of parentheses, the precedence of list operators such as `print`, `sort`, or `chmod` is either very high or very low depending on whether you are looking at the left side or the right side of the operator. For example, in

```
@ary = (1, 3, sort 4, 2);
print @ary; # prints 1324
```

the commas on the right of the `sort` are evaluated before the `sort`, but the commas on the left are evaluated after. In other words, list operators tend to gobble up all arguments that follow, and then act like a simple TERM with regard to the preceding expression. Be careful with parentheses:

```
# These evaluate exit before doing the print:
print($foo, exit); # Obviously not what you want.
print $foo, exit; # Nor is this.

# These do the print before evaluating exit:
(print $foo), exit; # This is what you want.
print($foo), exit; # Or this.
print ($foo), exit; # Or even this.
```

Also note that

```
print ($foo & 255) + 1, "\n";
```

probably doesn't do what you expect at first glance. The parentheses enclose the argument list for `print` which is evaluated (printing the result of `$foo & 255`). Then one is added to the return value of `print` (usually 1). The result is something like this:

```
1 + 1, "\n"; # Obviously not what you meant.
```

To do what you meant properly, you must write:

```
print(($foo & 255) + 1, "\n");
```

See *Named Unary Operators* for more discussion of this.

Also parsed as terms are the `do {}` and `eval {}` constructs, as well as subroutine and method calls, and the anonymous constructors `[]` and `{}`.

See also *Quote and Quote-like Operators* toward the end of this section, as well as *I/O Operators*.

The Arrow Operator

"->" is an infix dereference operator, just as it is in C and C++. If the right side is either a `[...]`, `{...}`, or a `(...)` subscript, then the left side must be either a hard or symbolic reference to an array, a hash, or a subroutine respectively. (Or technically speaking, a location capable of holding a hard reference, if it's an array or hash reference being used for assignment.) See *perlreftut* and *perlref*.

Otherwise, the right side is a method name or a simple scalar variable containing either the method name or a subroutine reference, and the left side must be either an object (a blessed reference) or a class name (that is, a package name). See *perlobj*.

Auto-increment and Auto-decrement

"++" and "--" work as in C. That is, if placed before a variable, they increment or decrement the variable by one before returning the value, and if placed after, increment or decrement after returning the value.

```
$i = 0; $j = 0;
print $i++; # prints 0
print ++$j; # prints 1
```

Note that just as in C, Perl doesn't define **when** the variable is incremented or decremented. You just know it will be done sometime before or after the value is returned. This also means that modifying a variable twice in the same statement will lead to undefined behaviour. Avoid statements like:

```
$i = $i ++;
print ++ $i + $i ++;
```

Perl will not guarantee what the result of the above statements is.

The auto-increment operator has a little extra builtin magic to it. If you increment a variable that is numeric, or that has ever been used in a numeric context, you get a normal increment. If, however, the variable has been used in only string contexts since it was set, and has a value that is not the empty string and matches the pattern `/^[a-zA-Z]*[0-9]*\z/`, the increment is done as a string, preserving each character within its range, with carry:

```
print ++($foo = '99'); # prints '100'
print ++($foo = 'a0'); # prints 'a1'
print ++($foo = 'Az'); # prints 'Ba'
print ++($foo = 'zz'); # prints 'aaa'
```

`undef` is always treated as numeric, and in particular is changed to 0 before incrementing (so that a post-increment of an `undef` value will return 0 rather than `undef`).

The auto-decrement operator is not magical.

Exponentiation

Binary `**` is the exponentiation operator. It binds even more tightly than unary minus, so `-2**4` is `-(2**4)`, not `(-2)**4`. (This is implemented using C's `pow(3)` function, which actually works on doubles internally.)

Symbolic Unary Operators

Unary `!` performs logical negation, i.e., "not". See also `not` for a lower precedence version of this.

Unary `-` performs arithmetic negation if the operand is numeric. If the operand is an identifier, a string consisting of a minus sign concatenated with the identifier is returned. Otherwise, if the string starts with a plus or minus, a string starting with the opposite sign is returned. One effect of these rules is that `-bareword` is equivalent to the string `"-bareword"`. If, however, the string begins with a non-alphabetic character (excluding `+` or `-`), Perl will attempt to convert the string to a numeric and the arithmetic negation is performed. If the string cannot be cleanly converted to a numeric, Perl will give the warning **Argument "the string" isn't numeric in negation (-) at**

Unary `~` performs bitwise negation, i.e., 1's complement. For example, `0666 & ~027` is `0640`. (See also *Integer Arithmetic* and *Bitwise String Operators*.) Note that the width of the result is platform-dependent: `~0` is 32 bits wide on a 32-bit platform, but 64 bits wide on a 64-bit platform, so if you are expecting a certain bit width, remember to use the `&` operator to mask off the excess bits.

Unary `+` has no effect whatsoever, even on strings. It is useful syntactically for separating a function name from a parenthesized expression that would otherwise be interpreted as the complete list of

function arguments. (See examples above under *Terms and List Operators (Leftward)*.)

Unary "\" creates a reference to whatever follows it. See *perlrefut* and *perlref*. Do not confuse this behavior with the behavior of backslash within a string, although both forms do convey the notion of protecting the next thing from interpolation.

Binding Operators

Binary "=~" binds a scalar expression to a pattern match. Certain operations search or modify the string `$_` by default. This operator makes that kind of operation work on some other string. The right argument is a search pattern, substitution, or transliteration. The left argument is what is supposed to be searched, substituted, or transliterated instead of the default `$_`. When used in scalar context, the return value generally indicates the success of the operation. Behavior in list context depends on the particular operator. See *Regex Quote-Like Operators* for details and *perlretut* for examples using these operators.

If the right argument is an expression rather than a search pattern, substitution, or transliteration, it is interpreted as a search pattern at run time.

Binary "!~" is just like "=~" except the return value is negated in the logical sense.

Multiplicative Operators

Binary "*" multiplies two numbers.

Binary "/" divides two numbers.

Binary "%" computes the modulus of two numbers. Given integer operands `$a` and `$b`: If `$b` is positive, then `$a % $b` is `$a` minus the largest multiple of `$b` that is not greater than `$a`. If `$b` is negative, then `$a % $b` is `$a` minus the smallest multiple of `$b` that is not less than `$a` (i.e. the result will be less than or equal to zero). Note that when `use integer` is in scope, "%" gives you direct access to the modulus operator as implemented by your C compiler. This operator is not as well defined for negative operands, but it will execute faster.

Binary "x" is the repetition operator. In scalar context or if the left operand is not enclosed in parentheses, it returns a string consisting of the left operand repeated the number of times specified by the right operand. In list context, if the left operand is enclosed in parentheses or is a list formed by `qw/STRING/`, it repeats the list. If the right operand is zero or negative, it returns an empty string or an empty list, depending on the context.

```
print '-' x 80; # print row of dashes

print "\t" x ($tab/8), ' ' x ($tab%8); # tab over

@ones = (1) x 80; # a list of 80 1's
@ones = (5) x @ones; # set all elements to 5
```

Additive Operators

Binary "+" returns the sum of two numbers.

Binary "-" returns the difference of two numbers.

Binary "." concatenates two strings.

Shift Operators

Binary "<<" returns the value of its left argument shifted left by the number of bits specified by the right argument. Arguments should be integers. (See also *Integer Arithmetic*.)

Binary ">>" returns the value of its left argument shifted right by the number of bits specified by the right argument. Arguments should be integers. (See also *Integer Arithmetic*.)

Note that both "<<" and ">>" in Perl are implemented directly using "<<" and ">>" in C. If `use integer` (see *Integer Arithmetic*) is in force then signed C integers are used, else unsigned C integers are used. Either way, the implementation isn't going to generate results larger than the size of the integer type Perl was built with (32 bits or 64 bits).

The result of overflowing the range of the integers is undefined because it is undefined also in C. In other words, using 32-bit integers, `1 << 32` is undefined. Shifting by a negative number of bits is also undefined.

Named Unary Operators

The various named unary operators are treated as functions with one argument, with optional parentheses.

If any list operator (`print()`, etc.) or any unary operator (`chdir()`, etc.) is followed by a left parenthesis as the next token, the operator and arguments within parentheses are taken to be of highest precedence, just like a normal function call. For example, because named unary operators are higher precedence than `||`:

```
chdir $foo      || die; # (chdir $foo) || die
chdir($foo)    || die; # (chdir $foo) || die
chdir ($foo)   || die; # (chdir $foo) || die
chdir +($foo)  || die; # (chdir $foo) || die
```

but, because `*` is higher precedence than named operators:

```
chdir $foo * 20; # chdir ($foo * 20)
chdir($foo) * 20; # (chdir $foo) * 20
chdir ($foo) * 20; # (chdir $foo) * 20
chdir +($foo) * 20; # chdir ($foo * 20)
```

```
rand 10 * 20; # rand (10 * 20)
rand(10) * 20; # (rand 10) * 20
rand (10) * 20; # (rand 10) * 20
rand +(10) * 20; # rand (10 * 20)
```

Regarding precedence, the filetest operators, like `-f`, `-M`, etc. are treated like named unary operators, but they don't follow this functional parenthesis rule. That means, for example, that `-f($file).".bak"` is equivalent to `-f "$file.bak"`.

See also *Terms and List Operators (Leftward)*.

Relational Operators

Binary "`<`" returns true if the left argument is numerically less than the right argument.

Binary "`>`" returns true if the left argument is numerically greater than the right argument.

Binary "`<=`" returns true if the left argument is numerically less than or equal to the right argument.

Binary "`>=`" returns true if the left argument is numerically greater than or equal to the right argument.

Binary "`lt`" returns true if the left argument is stringwise less than the right argument.

Binary "`gt`" returns true if the left argument is stringwise greater than the right argument.

Binary "`le`" returns true if the left argument is stringwise less than or equal to the right argument.

Binary "`ge`" returns true if the left argument is stringwise greater than or equal to the right argument.

Equality Operators

Binary "==" returns true if the left argument is numerically equal to the right argument.

Binary "!=" returns true if the left argument is numerically not equal to the right argument.

Binary "<=>" returns -1, 0, or 1 depending on whether the left argument is numerically less than, equal to, or greater than the right argument. If your platform supports NaNs (not-a-numbers) as numeric values, using them with "<=>" returns undef. NaN is not "<", "==", ">", "<=" or ">=" anything (even NaN), so those 5 return false. NaN != NaN returns true, as does NaN != anything else. If your platform doesn't support NaNs then NaN is just a string with numeric value 0.

```
perl -le '$a = "NaN"; print "No NaN support here" if $a == $a'
perl -le '$a = "NaN"; print "NaN support here" if $a != $a'
```

Binary "eq" returns true if the left argument is stringwise equal to the right argument.

Binary "ne" returns true if the left argument is stringwise not equal to the right argument.

Binary "cmp" returns -1, 0, or 1 depending on whether the left argument is stringwise less than, equal to, or greater than the right argument.

"lt", "le", "ge", "gt" and "cmp" use the collation (sort) order specified by the current locale if `use locale` is in effect. See *perllocale*.

Bitwise And

Binary "&" returns its operands ANDed together bit by bit. (See also *Integer Arithmetic* and *Bitwise String Operators*.)

Note that "&" has lower priority than relational operators, so for example the brackets are essential in a test like

```
print "Even\n" if ($x & 1) == 0;
```

Bitwise Or and Exclusive Or

Binary "|" returns its operands ORed together bit by bit. (See also *Integer Arithmetic* and *Bitwise String Operators*.)

Binary "^" returns its operands XORed together bit by bit. (See also *Integer Arithmetic* and *Bitwise String Operators*.)

Note that "|" and "^" have lower priority than relational operators, so for example the brackets are essential in a test like

```
print "false\n" if (8 | 2) != 10;
```

C-style Logical And

Binary "&&" performs a short-circuit logical AND operation. That is, if the left operand is false, the right operand is not even evaluated. Scalar or list context propagates down to the right operand if it is evaluated.

C-style Logical Or

Binary "||" performs a short-circuit logical OR operation. That is, if the left operand is true, the right operand is not even evaluated. Scalar or list context propagates down to the right operand if it is evaluated.

The || and && operators return the last value evaluated (unlike C's || and &&, which return 0 or 1). Thus, a reasonably portable way to find out the home directory might be:

```
$home = $ENV{'HOME'} || $ENV{'LOGDIR'} ||  
(getpwuid($<))[7] || die "You're homeless!\n";
```

In particular, this means that you shouldn't use this for selecting between two aggregates for assignment:

```
@a = @b || @c; # this is wrong  
@a = scalar(@b) || @c; # really meant this  
@a = @b ? @b : @c; # this works fine, though
```

As more readable alternatives to `&&` and `||` when used for control flow, Perl provides `and` and `or` operators (see below). The short-circuit behavior is identical. The precedence of "and" and "or" is much lower, however, so that you can safely use them after a list operator without the need for parentheses:

```
unlink "alpha", "beta", "gamma"  
or gripe(), next LINE;
```

With the C-style operators that would have been written like this:

```
unlink("alpha", "beta", "gamma")  
|| (gripe(), next LINE);
```

Using "or" for assignment is unlikely to do what you want; see below.

Range Operators

Binary `..` is the range operator, which is really two different operators depending on the context. In list context, it returns a list of values counting (up by ones) from the left value to the right value. If the left value is greater than the right value then it returns the empty list. The range operator is useful for writing `foreach (1..10)` loops and for doing slice operations on arrays. In the current implementation, no temporary array is created when the range operator is used as the expression in `foreach` loops, but older versions of Perl might burn a lot of memory when you write something like this:

```
for (1 .. 1_000_000) {  
# code  
}
```

The range operator also works on strings, using the magical auto-increment, see below.

In scalar context, `..` returns a boolean value. The operator is bistable, like a flip-flop, and emulates the line-range (comma) operator of `sed`, `awk`, and various editors. Each `..` operator maintains its own boolean state. It is false as long as its left operand is false. Once the left operand is true, the range operator stays true until the right operand is true, *AFTER* which the range operator becomes false again. It doesn't become false till the next time the range operator is evaluated. It can test the right operand and become false on the same evaluation it became true (as in `awk`), but it still returns true once. If you don't want it to test the right operand till the next evaluation, as in `sed`, just use three dots (`...`) instead of two. In all other regards, `...` behaves just like `..` does.

The right operand is not evaluated while the operator is in the "false" state, and the left operand is not evaluated while the operator is in the "true" state. The precedence is a little lower than `||` and `&&`. The value returned is either the empty string for false, or a sequence number (beginning with 1) for true. The sequence number is reset for each range encountered. The final sequence number in a range has the string "E0" appended to it, which doesn't affect its numeric value, but gives you something to search for if you want to exclude the endpoint. You can exclude the beginning point by waiting for the sequence number to be greater than 1.

If either operand of scalar `..` is a constant expression, that operand is considered true if it is equal (`==`) to the current input line number (the `$.` variable).

To be pedantic, the comparison is actually `int(EXPR) == int(EXPR)`, but that is only an issue if you use a floating point expression; when implicitly using `$.` as described in the previous paragraph, the comparison is `int(EXPR) == int($.)` which is only an issue when `$.` is set to a floating point value and you are not reading from a file. Furthermore, `"span" .. "spat"` or `2.18 .. 3.14` will not do what you want in scalar context because each of the operands are evaluated using their integer representation.

Examples:

As a scalar operator:

```
if (101 .. 200) { print; } # print 2nd hundred lines, short for
                        #   if ($. == 101 .. $. == 200) ...

next LINE if (1 .. /^$/); # skip header lines, short for
                        #   ... if ($. == 1 .. /^$/);
                        # (typically in a loop labeled LINE)

s/^/> / if (/^$/ .. eof()); # quote body

# parse mail messages
while (<>) {
    $in_header = 1 .. /^$/;
    $in_body   = /^$/ .. eof;
    if ($in_header) {
        # ...
    } else { # in body
        # ...
    }
} continue {
    close ARGV if eof;          # reset $. each file
}
```

Here's a simple example to illustrate the difference between the two range operators:

```
@lines = (" - Foo",
          "01 - Bar",
          "1 - Baz",
          " - Quux");

foreach (@lines) {
    if (/0/ .. /1/) {
        print "$_\n";
    }
}
```

This program will print only the line containing "Bar". If the range operator is changed to `...`, it will also print the "Baz" line.

And now some examples as a list operator:

```
for (101 .. 200) { print; } # print $_ 100 times
@foo = @foo[0 .. $#foo]; # an expensive no-op
```

```
@foo = @foo[$#foo-4 .. $#foo]; # slice last 5 items
```

The range operator (in list context) makes use of the magical auto-increment algorithm if the operands are strings. You can say

```
@alphabet = ('A' .. 'Z');
```

to get all normal letters of the English alphabet, or

```
$hexdigit = (0 .. 9, 'a' .. 'f')[$num & 15];
```

to get a hexadecimal digit, or

```
@z2 = ('01' .. '31'); print $z2[$mday];
```

to get dates with leading zeros. If the final value specified is not in the sequence that the magical increment would produce, the sequence goes until the next value would be longer than the final value specified.

Because each operand is evaluated in integer form, `2.18 .. 3.14` will return two elements in list context.

```
@list = (2.18 .. 3.14); # same as @list = (2 .. 3);
```

Conditional Operator

Ternary `"?:"` is the conditional operator, just as in C. It works much like an if-then-else. If the argument before the `?` is true, the argument before the `:` is returned, otherwise the argument after the `:` is returned. For example:

```
printf "I have %d dog%s.\n", $n,
      ($n == 1) ? '' : "s";
```

Scalar or list context propagates downward into the 2nd or 3rd argument, whichever is selected.

```
$a = $ok ? $b : $c; # get a scalar
@a = $ok ? @b : @c; # get an array
$a = $ok ? @b : @c; # oops, that's just a count!
```

The operator may be assigned to if both the 2nd and 3rd arguments are legal lvalues (meaning that you can assign to them):

```
($a_or_b ? $a : $b) = $c;
```

Because this operator produces an assignable result, using assignments without parentheses will get you in trouble. For example, this:

```
$a % 2 ? $a += 10 : $a += 2
```

Really means this:

```
((($a % 2) ? ($a += 10) : $a) += 2
```

Rather than this:

```
($a % 2) ? ($a += 10) : ($a += 2)
```

That should probably be written more simply as:

```
$a += ($a % 2) ? 10 : 2;
```

Assignment Operators

"=" is the ordinary assignment operator.

Assignment operators work as in C. That is,

```
$a += 2;
```

is equivalent to

```
$a = $a + 2;
```

although without duplicating any side effects that dereferencing the lvalue might trigger, such as from tie(). Other assignment operators work similarly. The following are recognized:

```

**=      +=      *=      &&=      <<=      &&&=
          -=      /=      |=      >>=      ||=
          .=      %=      ^=
          x=

```

Although these are grouped by family, they all have the precedence of assignment.

Unlike in C, the scalar assignment operator produces a valid lvalue. Modifying an assignment is equivalent to doing the assignment and then modifying the variable that was assigned to. This is useful for modifying a copy of something, like this:

```
($tmp = $global) =~ tr [A-Z] [a-z];
```

Likewise,

```
($a += 2) *= 3;
```

is equivalent to

```
$a += 2;
$a *= 3;
```

Similarly, a list assignment in list context produces the list of lvalues assigned to, and a list assignment in scalar context returns the number of elements produced by the expression on the right hand side of the assignment.

Comma Operator

Binary "," is the comma operator. In scalar context it evaluates its left argument, throws that value away, then evaluates its right argument and returns that value. This is just like C's comma operator.

In list context, it's just the list argument separator, and inserts both its arguments into the list.

The => operator is a synonym for the comma, but forces any word (consisting entirely of word characters) to its left to be interpreted as a string (as of 5.001). This includes words that might otherwise be considered a constant or function call.

```
use constant FOO => "something";
```

```
my %h = ( FOO => 23 );
```

is equivalent to:

```
my %h = ("FOO", 23);
```

It is *NOT*:

```
my %h = ("something", 23);
```

If the argument on the left is not a word, it is first interpreted as an expression, and then the string value of that is used.

The => operator is helpful in documenting the correspondence between keys and values in hashes, and other paired elements in lists.

```
%hash = ( $key => $value );  
login( $username => $password );
```

List Operators (Rightward)

On the right side of a list operator, it has very low precedence, such that it controls all comma-separated expressions found there. The only operators with lower precedence are the logical operators "and", "or", and "not", which may be used to evaluate calls to list operators without the need for extra parentheses:

```
open HANDLE, "filename"  
or die "Can't open: $!\n";
```

See also discussion of list operators in *Terms and List Operators (Leftward)*.

Logical Not

Unary "not" returns the logical negation of the expression to its right. It's the equivalent of "!" except for the very low precedence.

Logical And

Binary "and" returns the logical conjunction of the two surrounding expressions. It's equivalent to && except for the very low precedence. This means that it short-circuits: i.e., the right expression is evaluated only if the left expression is true.

Logical or and Exclusive Or

Binary "or" returns the logical disjunction of the two surrounding expressions. It's equivalent to || except for the very low precedence. This makes it useful for control flow

```
print FH $data or die "Can't write to FH: $!";
```

This means that it short-circuits: i.e., the right expression is evaluated only if the left expression is false. Due to its precedence, you should probably avoid using this for assignment, only for control flow.

```
$a = $b or $c; # bug: this is wrong  
($a = $b) or $c; # really means this  
$a = $b || $c; # better written this way
```

However, when it's a list-context assignment and you're trying to use "||" for control flow, you probably need "or" so that the assignment takes higher precedence.

```
@info = stat($file) || die; # oops, scalar sense of stat!  
@info = stat($file) or die; # better, now @info gets its due
```

Then again, you could always use parentheses.

Binary "xor" returns the exclusive-OR of the two surrounding expressions. It cannot short circuit, of course.

C Operators Missing From Perl

Here is what C has that Perl doesn't:

unary &

Address-of operator. (But see the "\ " operator for taking a reference.)

unary *

Dereference-address operator. (Perl's prefix dereferencing operators are typed: \$, @, %, and &.)

(TYPE)

Type-casting operator.

Quote and Quote-like Operators

While we usually think of quotes as literal values, in Perl they function as operators, providing various kinds of interpolating and pattern matching capabilities. Perl provides customary quote characters for these behaviors, but also provides a way for you to choose your quote character for any of them. In the following table, a {} represents any pair of delimiters you choose.

	Customary	Generic	Meaning	Interpolates
' '	q{ }	Literal	no	
" "	qq{ }	Literal	yes	
` `	qx{ }	Command	yes*	
	qw{ }	Word list	no	
//	m{ }	Pattern match	yes*	
	qr{ }	Pattern	yes*	
	s{ }{ }	Substitution	yes*	
	tr{ }{ }	Transliteration	no (but see below)	
	<<EOF		here-doc	yes*

* unless the delimiter is ' '.

Non-bracketing delimiters use the same character fore and aft, but the four sorts of brackets (round, angle, square, curly) will all nest, which means that

```
q{foo{bar}baz}
```

is the same as

```
'foo{bar}baz'
```

Note, however, that this does not always work for quoting Perl code:

```
$s = q{ if($a eq " ") ... }; # WRONG
```

is a syntax error. The `Text::Balanced` module (from CPAN, and starting from Perl 5.8 part of the standard distribution) is able to do this properly.

There can be whitespace between the operator and the quoting characters, except when # is being used as the quoting character. `q#foo#` is parsed as the string `foo`, while `q #foo#` is the operator `q` followed by a comment. Its argument will be taken from the next line. This allows you to write:

```
s {foo} # Replace foo
      {bar} # with bar.
```

The following escape sequences are available in constructs that interpolate and in transliterations.

```
\t tab (HT, TAB)
\n newline (NL)
\r return (CR)
\f form feed (FF)
\b backspace (BS)
\a alarm (bell) (BEL)
\e escape (ESC)
\033 octal char (ESC)
\x1b hex char (ESC)
\x{263a} wide hex char (SMILEY)
\c[ control char (ESC)
\N{name} named Unicode character
```

NOTE: Unlike C and other languages, Perl has no `\v` escape sequence for the vertical tab (VT - ASCII 11).

The following escape sequences are available in constructs that interpolate but not in transliterations.

```
\l lowercase next char
\u uppercase next char
\L lowercase till \E
\U uppercase till \E
\E end case modification
\Q quote non-word characters till \E
```

If use locale is in effect, the case map used by `\l`, `\L`, `\u` and `\U` is taken from the current locale. See *perllocale*. If Unicode (for example, `\N{}` or wide hex characters of 0x100 or beyond) is being used, the case map used by `\l`, `\L`, `\u` and `\U` is as defined by Unicode. For documentation of `\N{name}`, see *charnames*.

All systems use the virtual "`\n`" to represent a line terminator, called a "newline". There is no such thing as an unvarying, physical newline character. It is only an illusion that the operating system, device drivers, C libraries, and Perl all conspire to preserve. Not all systems read "`\r`" as ASCII CR and "`\n`" as ASCII LF. For example, on a Mac, these are reversed, and on systems without line terminator, printing "`\n`" may emit no actual data. In general, use "`\n`" when you mean a "newline" for your system, but use the literal ASCII when you need an exact character. For example, most networking protocols expect and prefer a CR+LF ("`\015\012`" or "`\cM\cJ`") for line terminators, and although they often accept just "`\012`", they seldom tolerate just "`\015`". If you get in the habit of using "`\n`" for networking, you may be burned some day.

For constructs that do interpolate, variables beginning with "\$" or "@" are interpolated. Subscripted variables such as `$a[3]` or `$href->{key}[0]` are also interpolated, as are array and hash slices. But method calls such as `$obj->meth` are not.

Interpolating an array or slice interpolates the elements in order, separated by the value of "\$", so is equivalent to interpolating `join $", @array`. "Punctuation" arrays such as `@+` are only interpolated if the name is enclosed in braces `@{+}`.

You cannot include a literal \$ or @ within a `\Q` sequence. An unescaped \$ or @ interpolates the corresponding variable, while escaping will cause the literal string `\$` to be inserted. You'll need to

write something like `m/\Quser\E@\Qhost/`.

Patterns are subject to an additional level of interpretation as a regular expression. This is done as a second pass, after variables are interpolated, so that regular expressions may be incorporated into the pattern from the variables. If this is not what you want, use `\Q` to interpolate a variable literally.

Apart from the behavior described above, Perl does not expand multiple levels of interpolation. In particular, contrary to the expectations of shell programmers, back-quotes do *NOT* interpolate within double quotes, nor do single quotes impede evaluation of variables when used within double quotes.

Regexp Quote-Like Operators

Here are the quote-like operators that apply to pattern matching and related activities.

?PATTERN?

This is just like the `/pattern/` search, except that it matches only once between calls to the `reset()` operator. This is a useful optimization when you want to see only the first occurrence of something in each file of a set of files, for instance. Only `??` patterns local to the current package are reset.

```
while (<>) {
  if (?^$?) {
    # blank line between header and body
  }
  } continue {
  reset if eof;      # clear ?? status for next file
}
```

This usage is vaguely deprecated, which means it just might possibly be removed in some distant future version of Perl, perhaps somewhere around the year 2168.

m/PATTERN/cgimosx

/PATTERN/cgimosx

Searches a string for a pattern match, and in scalar context returns true if it succeeds, false if it fails. If no string is specified via the `=~` or `!~` operator, the `$_` string is searched. (The string specified with `=~` need not be an lvalue--it may be the result of an expression evaluation, but remember the `=~` binds rather tightly.) See also *perlre*. See *perllocale* for discussion of additional considerations that apply when `use locale` is in effect.

Options are:

```
  c Do not reset search position on a failed match when /g is
  in effect.
  g Match globally, i.e., find all occurrences.
  i Do case-insensitive pattern matching.
  m Treat string as multiple lines.
  o Compile pattern only once.
  s Treat string as single line.
  x Use extended regular expressions.
```

If `/` is the delimiter then the initial `m` is optional. With the `m` you can use any pair of non-alphanumeric, non-whitespace characters as delimiters. This is particularly useful for matching path names that contain `/`, to avoid LTS (leaning toothpick syndrome). If `?` is the delimiter, then the match-only-once rule of `?PATTERN?` applies. If `""` is the delimiter, no interpolation is performed on the `PATTERN`.

`PATTERN` may contain variables, which will be interpolated (and the pattern recompiled) every time the pattern search is evaluated, except for when the delimiter is a single quote. (Note that `$ (, $)`, and `$ |` are not interpolated because they look like

end-of-string tests.) If you want such a pattern to be compiled only once, add a `/o` after the trailing delimiter. This avoids expensive run-time recompilations, and is useful when the value you are interpolating won't change over the life of the script. However, mentioning `/o` constitutes a promise that you won't change the variables in the pattern. If you change them, Perl won't even notice. See also `qr/STRING/imosx`.

If the PATTERN evaluates to the empty string, the last *successfully* matched regular expression is used instead. In this case, only the `g` and `c` flags on the empty pattern is honoured - the other flags are taken from the original pattern. If no match has previously succeeded, this will (silently) act instead as a genuine empty pattern (which will always match).

If the `/g` option is not used, `m//` in list context returns a list consisting of the subexpressions matched by the parentheses in the pattern, i.e., (`$1`, `$2`, `$3...`). (Note that here `$1` etc. are also set, and that this differs from Perl 4's behavior.) When there are no parentheses in the pattern, the return value is the list (`1`) for success. With or without parentheses, an empty list is returned upon failure.

Examples:

```
open(TTY, '/dev/tty');
<TTY> =~ /^y/i && foo(); # do foo if desired

if (/Version: *([0-9.]*)/) { $version = $1; }

next if m#^/usr/spool/uucp#;

# poor man's grep
$args = shift;
while (<>) {
print if /$args/o; # compile only once
}

if (($F1, $F2, $Etc) = ($foo =~ /^(\S+)\s+(\S+)\s*(.*)/))
```

This last example splits `$foo` into the first two words and the remainder of the line, and assigns those three fields to `$F1`, `$F2`, and `$Etc`. The conditional is true if any variables were assigned, i.e., if the pattern matched.

The `/g` modifier specifies global pattern matching--that is, matching as many times as possible within the string. How it behaves depends on the context. In list context, it returns a list of the substrings matched by any capturing parentheses in the regular expression. If there are no parentheses, it returns a list of all the matched strings, as if there were parentheses around the whole pattern.

In scalar context, each execution of `m/g` finds the next match, returning true if it matches, and false if there is no further match. The position after the last match can be read or set using the `pos()` function; see "*pos*" in *perlfunc*. A failed match normally resets the search position to the beginning of the string, but you can avoid that by adding the `/c` modifier (e.g. `m/gc`). Modifying the target string also resets the search position.

You can intermix `m/g` matches with `m/\G.../g`, where `\G` is a zero-width assertion that matches the exact position where the previous `m/g`, if any, left off. Without the `/g` modifier, the `\G` assertion still anchors at `pos()`, but the match is of course only attempted once. Using `\G` without `/g` on a target string that has not previously had a `/g` match applied to it is the same as using the `\A` assertion to match the beginning of the string. Note also that, currently, `\G` is only properly supported when anchored at the very beginning of the pattern.

Examples:

```

# list context
($one,$five,$fifteen) = (`uptime` =~ /(\d+\.\d+)/g);

# scalar context
$/ = "";
while (defined($paragraph = <>)) {
while ($paragraph =~ /[a-z](['"])*[.!?]+(['"])*\s/g) {
    $sentences++;
}
}
print "$sentences\n";

# using m//gc with \G
$_ = "ppooqppq";
while ($i++ < 2) {
    print "1: ";
    print $_ while /(o)/gc; print "'", pos=", pos, "\n";
    print "2: ";
    print $_ if /\G(q)/gc; print "'", pos=", pos, "\n";
    print "3: ";
    print $_ while /(p)/gc; print "'", pos=", pos, "\n";
}
print "Final: '$1', pos=",pos,"\n" if /\G(.)/;

```

The last example should print:

```

1: 'oo', pos=4
2: 'q', pos=5
3: 'pp', pos=7
1: '', pos=7
2: 'q', pos=8
3: '', pos=8
Final: 'q', pos=8

```

Notice that the final match matched `q` instead of `p`, which a match without the `\G` anchor would have done. Also note that the final match did not update `pos` -- `pos` is only updated on a `/g` match. If the final match did indeed match `p`, it's a good bet that you're running an older (pre-5.6.0) Perl.

A useful idiom for `lex`-like scanners is `/\G.../gc`. You can combine several regexps like this to process a string part-by-part, doing different actions depending on which regexp matched. Each regexp tries to match where the previous one leaves off.

```

$_ = <<'EOL';
$url = new URI::URL "http://www/"; die if $url eq "xXx";
EOL
LOOP:
{
    print(" digits"), redo LOOP if /\G\d+\b[.,;]?\s*/gc;
    print(" lowercase"), redo LOOP if /\G[a-z]+\b[.,;]?\s*/gc;
    print(" UPPERCASE"), redo LOOP if /\G[A-Z]+\b[.,;]?\s*/gc;
    print(" Capitalized"), redo LOOP if
/\G[A-Z][a-z]+\b[.,;]?\s*/gc;
    print(" MiXeD"), redo LOOP if /\G[A-Za-z]+\b[.,;]?\s*/gc;
    print(" alphanumeric"), redo LOOP if
/\G[A-Za-z0-9]+\b[.,;]?\s*/gc;
    print(" line-noise"), redo LOOP if /\G[^A-Za-z0-9]+/gc;
    print ". That's all!\n";
}

```

```
}

```

Here is the output (split into several lines):

```
line-noise lowercase line-noise lowercase UPPERCASE line-noise
UPPERCASE line-noise lowercase line-noise lowercase line-noise
lowercase lowercase line-noise lowercase lowercase line-noise
MiXeD line-noise. That's all!
```

`q/STRING/`

`'STRING'`

A single-quoted, literal string. A backslash represents a backslash unless followed by the delimiter or another backslash, in which case the delimiter or backslash is interpolated.

```
$foo = q!I said, "You said, 'She said it.'!";
$bar = q('This is it.');
```

```
$baz = '\n'; # a two-character string
```

`qq/STRING/`

`"STRING"`

A double-quoted, interpolated string.

```
$_ .= qq
  (** The previous line contains the naughty word "$1".\n)
if /\b(tcl|java|python)\b/i; # :-)
$baz = "\n"; # a one-character string
```

`qr/STRING/imosx`

This operator quotes (and possibly compiles) its *STRING* as a regular expression. *STRING* is interpolated the same way as *PATTERN* in `m/PATTERN/`. If `""` is used as the delimiter, no interpolation is done. Returns a Perl value which may be used instead of the corresponding `/STRING/imosx` expression.

For example,

```
$rex = qr/my.STRING/is;
s/$rex/foo/;
```

is equivalent to

```
s/my.STRING/foo/;
```

The result may be used as a subpattern in a match:

```
$re = qr/$pattern/;
$string =~ /foo${re}bar/; # can be interpolated in other
patterns
$string =~ $re; # or used standalone
$string =~ /$re/; # or this way
```

Since Perl may compile the pattern at the moment of execution of `qr()` operator, using `qr()` may have speed advantages in some situations, notably if the result of `qr()` is used standalone:

```
sub match {
  my $patterns = shift;
  my @compiled = map qr/$_/i, @$patterns;
  grep {
```

```

    my $success = 0;
    foreach my $pat (@compiled) {
    $success = 1, last if /$pat/;
    }
    $success;
} @_;
}

```

Precompilation of the pattern into an internal representation at the moment of `qr()` avoids a need to recompile the pattern every time a match `/$pat/` is attempted. (Perl has many other internal optimizations, but none would be triggered in the above example if we did not use `qr()` operator.)

Options are:

```

i Do case-insensitive pattern matching.
m Treat string as multiple lines.
o Compile pattern only once.
s Treat string as single line.
x Use extended regular expressions.

```

See *perltre* for additional information on valid syntax for `STRING`, and for a detailed look at the semantics of regular expressions.

`qx/STRING/`
``STRING``

A string which is (possibly) interpolated and then executed as a system command with `/bin/sh` or its equivalent. Shell wildcards, pipes, and redirections will be honored. The collected standard output of the command is returned; standard error is unaffected. In scalar context, it comes back as a single (potentially multi-line) string, or `undef` if the command failed. In list context, returns a list of lines (however you've defined lines with `$/` or `$INPUT_RECORD_SEPARATOR`), or an empty list if the command failed.

Because backticks do not affect standard error, use shell file descriptor syntax (assuming the shell supports this) if you care to address this. To capture a command's `STDERR` and `STDOUT` together:

```
$output = `cmd 2>&1`;
```

To capture a command's `STDOUT` but discard its `STDERR`:

```
$output = `cmd 2>/dev/null`;
```

To capture a command's `STDERR` but discard its `STDOUT` (ordering is important here):

```
$output = `cmd 2>&1 1>/dev/null`;
```

To exchange a command's `STDOUT` and `STDERR` in order to capture the `STDERR` but leave its `STDOUT` to come out the old `STDERR`:

```
$output = `cmd 3>&1 1>&2 2>&3 3>&-`;
```

To read both a command's `STDOUT` and its `STDERR` separately, it's easiest to redirect them separately to files, and then read from those files when the program is done:

```
system("program args 1>program.stdout 2>program.stderr");
```

Using single-quote as a delimiter protects the command from Perl's double-quote

interpolation, passing it on to the shell instead:

```
$perl_info = qx(ps $$);           # that's Perl's $$
$shell_info = qx'ps $$' ;        # that's the new shell's
$$
```

How that string gets evaluated is entirely subject to the command interpreter on your system. On most platforms, you will have to protect shell metacharacters if you want them treated literally. This is in practice difficult to do, as it's unclear how to escape which characters. See *perlsec* for a clean and safe example of a manual `fork()` and `exec()` to emulate backticks safely.

On some platforms (notably DOS-like ones), the shell may not be capable of dealing with multiline commands, so putting newlines in the string may not get you what you want. You may be able to evaluate multiple commands in a single line by separating them with the command separator character, if your shell supports that (e.g. `;` on many Unix shells; `&` on the Windows NT `cmd` shell).

Beginning with v5.6.0, Perl will attempt to flush all files opened for output before starting the child process, but this may not be supported on some platforms (see *perlport*). To be safe, you may need to set `$|` (`$AUTOFLUSH` in English) or call the `autoflush()` method of `IO::Handle` on any open handles.

Beware that some command shells may place restrictions on the length of the command line. You must ensure your strings don't exceed this limit after any necessary interpolations. See the platform-specific release notes for more details about your particular environment.

Using this operator can lead to programs that are difficult to port, because the shell commands called vary between systems, and may in fact not be present at all. As one example, the `type` command under the POSIX shell is very different from the `type` command under DOS. That doesn't mean you should go out of your way to avoid backticks when they're the right way to get something done. Perl was made to be a glue language, and one of the things it glues together is commands. Just understand what you're getting yourself into.

See *I/O Operators* for more discussion.

qw/STRING/

Evaluates to a list of the words extracted out of `STRING`, using embedded whitespace as the word delimiters. It can be understood as being roughly equivalent to:

```
split(' ', qw/STRING/);
```

the differences being that it generates a real list at compile time, and in scalar context it returns the last element in the list. So this expression:

```
qw(foo bar baz)
```

is semantically equivalent to the list:

```
'foo', 'bar', 'baz'
```

Some frequently seen examples:

```
use POSIX qw( setlocale localeconv )
@EXPORT = qw( foo bar baz );
```

A common mistake is to try to separate the words with comma or to put comments into a multi-line `qw`-string. For this reason, the `use warnings` pragma and the `-w` switch (that is, the `$^W` variable) produces warnings if the `STRING` contains the `,` or the `#` character.

s/PATTERN/REPLACEMENT/egimosx

Searches a string for a pattern, and if found, replaces that pattern with the replacement text and returns the number of substitutions made. Otherwise it returns false (specifically, the empty string).

If no string is specified via the `=~` or `!~` operator, the `$_` variable is searched and modified. (The string specified with `=~` must be scalar variable, an array element, a hash element, or an assignment to one of those, i.e., an lvalue.)

If the delimiter chosen is a single quote, no interpolation is done on either the PATTERN or the REPLACEMENT. Otherwise, if the PATTERN contains a `$` that looks like a variable rather than an end-of-string test, the variable will be interpolated into the pattern at run-time. If you want the pattern compiled only once the first time the variable is interpolated, use the `/o` option. If the pattern evaluates to the empty string, the last successfully executed regular expression is used instead. See *perlre* for further explanation on these. See *perllocale* for discussion of additional considerations that apply when `use locale` is in effect.

Options are:

```
e Evaluate the right side as an expression.
g Replace globally, i.e., all occurrences.
i Do case-insensitive pattern matching.
m Treat string as multiple lines.
o Compile pattern only once.
s Treat string as single line.
x Use extended regular expressions.
```

Any non-alphanumeric, non-whitespace delimiter may replace the slashes. If single quotes are used, no interpretation is done on the replacement string (the `/e` modifier overrides this, however). Unlike Perl 4, Perl 5 treats backticks as normal delimiters; the replacement text is not evaluated as a command. If the PATTERN is delimited by bracketing quotes, the REPLACEMENT has its own pair of quotes, which may or may not be bracketing quotes, e.g., `s(foo)(bar)` or `s<foo>/bar/`. A `/e` will cause the replacement portion to be treated as a full-fledged Perl expression and evaluated right then and there. It is, however, syntax checked at compile-time. A second `e` modifier will cause the replacement portion to be *eval*ed before being run as a Perl expression.

Examples:

```
s/\bgreen\b/mauve/g; # don't change wintergreen

$path =~ s|/usr/bin|/usr/local/bin|;

s/Login: $foo/Login: $bar/; # run-time pattern

($foo = $bar) =~ s/this/that/; # copy first, then change

$count = ($paragraph =~ s/Mister\b/Mr./g); # get
change-count

$_ = 'abc123xyz';
s/\d+/$&*2/e; # yields 'abc246xyz'
s/\d+/sprintf("%5d",$&)/e; # yields 'abc 246xyz'
s/\w/$& x 2/eg; # yields 'aabbcc 224466xxyyzz'

s/%(.)/$percent{$1}/g; # change percent escapes; no /e
s/%(.)/$percent{$1} || $&/ge; # expr now, so /e
s/^(\\w+)/&pod($1)/ge; # use function call
```

```

# expand variables in $_, but dynamics only, using
# symbolic dereferencing
s/\$(\w+)/${$1}/g;

# Add one to the value of any numbers in the string
s/(\d+)/1 + $1/eg;

# This will expand any embedded scalar variable
# (including lexicals) in $_ : First $1 is interpolated
# to the variable name, and then evaluated
s/(\$\w+)/$1/eeg;

# Delete (most) C comments.
$program =~ s {
/\* # Match the opening delimiter.
.*? # Match a minimal number of characters.
*/ # Match the closing delimiter.
} [lgsx];

s/^\s*(.*?)\s*$/$1/; # trim whitespace in $_, expensively

for ($variable) { # trim whitespace in $variable, cheap
s/^\s+//;
s/\s+$//;
}

s/([ ]*) *([ ]*)/$2 $1/; # reverse 1st two fields

```

Note the use of \$ instead of \ in the last example. Unlike **sed**, we use the `<digit>` form in only the left hand side. Anywhere else it's `<digit>`.

Occasionally, you can't use just a /g to get all the changes to occur that you might want. Here are two common cases:

```

# put commas in the right places in an integer
1 while s/(\d)(\d\d\d)(?! \d)/$1,$2/g;

# expand tabs to 8-column spacing
1 while s/\t+/' ' x (length($&)*8 - length($`)%8)/e;

```

`tr/SEARCHLIST/REPLACEMENTLIST/cds`
`y/SEARCHLIST/REPLACEMENTLIST/cds`

Transliterates all occurrences of the characters found in the search list with the corresponding character in the replacement list. It returns the number of characters replaced or deleted. If no string is specified via the `=~` or `!~` operator, the `$_` string is transliterated. (The string specified with `=~` must be a scalar variable, an array element, a hash element, or an assignment to one of those, i.e., an lvalue.)

A character range may be specified with a hyphen, so `tr/A-J/0-9/` does the same replacement as `tr/ACEGIBDFHJ/0246813579/`. For **sed** devotees, `y` is provided as a synonym for `tr`. If the SEARCHLIST is delimited by bracketing quotes, the REPLACEMENTLIST has its own pair of quotes, which may or may not be bracketing quotes, e.g., `tr[A-Z][a-z]` or `tr(+\-*//)ABCD/`.

Note that `tr` does **not** do regular expression character classes such as `\d` or `[:lower:]`. The `<tr>` operator is not equivalent to the `tr(1)` utility. If you want to map strings between lower/upper cases, see "`lc`" in *perlfunc* and "`uc`" in *perlfunc*, and in general consider using the `s` operator if you need regular expressions.

Note also that the whole range idea is rather unportable between character sets--and even within character sets they may cause results you probably didn't expect. A sound principle is to use only ranges that begin from and end at either alphabets of equal case (a-e, A-E), or digits (0-4). Anything else is unsafe. If in doubt, spell out the character sets in full.

Options:

```
c Complement the SEARCHLIST.
d Delete found but unreplaced characters.
s Squash duplicate replaced characters.
```

If the `/c` modifier is specified, the SEARCHLIST character set is complemented. If the `/d` modifier is specified, any characters specified by SEARCHLIST not found in REPLACEMENTLIST are deleted. (Note that this is slightly more flexible than the behavior of some `tr` programs, which delete anything they find in the SEARCHLIST, period.) If the `/s` modifier is specified, sequences of characters that were transliterated to the same character are squashed down to a single instance of the character.

If the `/d` modifier is used, the REPLACEMENTLIST is always interpreted exactly as specified. Otherwise, if the REPLACEMENTLIST is shorter than the SEARCHLIST, the final character is replicated till it is long enough. If the REPLACEMENTLIST is empty, the SEARCHLIST is replicated. This latter is useful for counting characters in a class or for squashing character sequences in a class.

Examples:

```
$ARGV[1] =~ tr/A-Z/a-z/; # canonicalize to lower case

$cnt = tr/***/; # count the stars in $_

$cnt = $sky =~ tr/***/; # count the stars in $sky

$cnt = tr/0-9//; # count the digits in $_

tr/a-zA-Z//s; # bookkeeper -> bokeper

($HOST = $host) =~ tr/a-z/A-Z/;

tr/a-zA-Z/ /cs; # change non-alphas to single space

tr [\200-\377]
 [\000-\177]; # delete 8th bit
```

If multiple transliterations are given for a character, only the first one is used:

```
tr/AAA/XYZ/
```

will transliterate any A to X.

Because the transliteration table is built at compile time, neither the SEARCHLIST nor the REPLACEMENTLIST are subjected to double quote interpolation. That means that if you want to use variables, you must use an `eval()`:

```
eval "tr/$oldlist/$newlist/";
die "$@" if $@;

eval "tr/$oldlist/$newlist/, 1" or die $@;
```

<<EOF

A line-oriented form of quoting is based on the shell "here-document" syntax.

Following a << you specify a string to terminate the quoted material, and all lines following the current line down to the terminating string are the value of the item. The terminating string may be either an identifier (a word), or some quoted text. If quoted, the type of quotes you use determines the treatment of the text, just as in regular quoting. An unquoted identifier works like double quotes. There must be no space between the << and the identifier, unless the identifier is quoted. (If you put a space it will be treated as a null identifier, which is valid, and matches the first empty line.) The terminating string must appear by itself (unquoted and with no surrounding whitespace) on the terminating line.

```
print <<EOF;
The price is $Price.
EOF

print << "EOF"; # same as above
The price is $Price.
EOF

print << `EOC`; # execute commands
echo hi there
echo lo there
EOC

print <<"foo", <<"bar"; # you can stack them
I said foo.
foo
I said bar.
bar

myfunc(<< "THIS", 23, <<'THAT');
Here's a line
or two.
THIS
and here's another.
THAT
```

Just don't forget that you have to put a semicolon on the end to finish the statement, as Perl doesn't know you're not going to try to do this:

```
print <<ABC
179231
ABC
+ 20;
```

If you want your here-docs to be indented with the rest of the code, you'll need to remove leading whitespace from each line manually:

```
($quote = <<'FINIS') =~ s/^\s+//gm;
    The Road goes ever on and on,
    down from the door where it began.
FINIS
```

If you use a here-doc within a delimited construct, such as in `s///eg`, the quoted material must come on the lines following the final delimiter. So instead of

```
s/this/<<E . 'that'
the other
E
. 'more '/eg;
```

you have to write

```
s/this/<<E . 'that'
. 'more '/eg;
the other
E
```

If the terminating identifier is on the last line of the program, you must be sure there is a newline after it; otherwise, Perl will give the warning **Can't find string terminator "END" anywhere before EOF...**

Additionally, the quoting rules for the identifier are not related to Perl's quoting rules -- `q()`, `qq()`, and the like are not supported in place of `'` and `"`, and the only interpolation is for backslashing the quoting character:

```
print << "abc\"def";
testing...
abc"def
```

Finally, quoted strings cannot span multiple lines. The general rule is that the identifier must be a string literal. Stick with that, and you should be safe.

Gory details of parsing quoted constructs

When presented with something that might have several different interpretations, Perl uses the **DWIM** (that's "Do What I Mean") principle to pick the most probable interpretation. This strategy is so successful that Perl programmers often do not suspect the ambivalence of what they write. But from time to time, Perl's notions differ substantially from what the author honestly meant.

This section hopes to clarify how Perl handles quoted constructs. Although the most common reason to learn this is to unravel labyrinthine regular expressions, because the initial steps of parsing are the same for all quoting operators, they are all discussed together.

The most important Perl parsing rule is the first one discussed below: when processing a quoted construct, Perl first finds the end of that construct, then interprets its contents. If you understand this rule, you may skip the rest of this section on the first reading. The other rules are likely to contradict the user's expectations much less frequently than this first one.

Some passes discussed below are performed concurrently, but because their results are the same, we consider them individually. For different quoting constructs, Perl performs different numbers of passes, from one to five, but these passes are always performed in the same order.

Finding the end

The first pass is finding the end of the quoted construct, whether it be a multicharacter delimiter `"\nEOF\n"` in the `<<EOF` construct, a `/` that terminates a `qq//` construct, a `]` which terminates `qq[]` construct, or a `>` which terminates a fileglob started with `<`.

When searching for single-character non-pairing delimiters, such as `/`, combinations of `\\` and `\/` are skipped. However, when searching for single-character pairing delimiter like `[`, combinations of `\\`, `\]`, and `\[` are all skipped, and nested `[,]` are skipped as well. When searching for multicharacter delimiters, nothing is skipped.

For constructs with three-part delimiters (`s///`, `y///`, and `tr///`), the search is repeated once more.

During this search no attention is paid to the semantics of the construct. Thus:

```
"$hash{"$foo/$bar"}"
```

or:

```
m/
bar # NOT a comment, this slash / terminated m//!
```

/x

do not form legal quoted expressions. The quoted part ends on the first " and /, and the rest happens to be a syntax error. Because the slash that terminated m// was followed by a SPACE, the example above is not m//x, but rather m// with no /x modifier. So the embedded # is interpreted as a literal #.

Also no attention is paid to \c\ during this search. Thus the second \ in qq/\c\ is interpreted as a part of \/, and the following / is not recognized as a delimiter. Instead, use \034 or \x1c at the end of quoted constructs.

Removal of backslashes before delimiters

During the second pass, text between the starting and ending delimiters is copied to a safe location, and the \ is removed from combinations consisting of \ and delimiter--or delimiters, meaning both starting and ending delimiters will should these differ. This removal does not happen for multi-character delimiters. Note that the combination \\ is left intact, just as it was.

Starting from this step no information about the delimiters is used in parsing.

Interpolation

The next step is interpolation in the text obtained, which is now delimiter-independent. There are four different cases.

```
<<'EOF', m' ', s' ', tr///, y///
```

No interpolation is performed.

```
' ', q//
```

The only interpolation is removal of \ from pairs \\.

```
"", ``, qq//, qx//, <file*glob>
```

\Q, \U, \u, \L, \l (possibly paired with \E) are converted to corresponding Perl constructs. Thus, "\$foo\Qbaz\$bar" is converted to \$foo . (quotemeta("baz" . \$bar)) internally. The other combinations are replaced with appropriate expansions.

Let it be stressed that *whatever falls between \Q and \E* is interpolated in the usual way. Something like "\Q\\E" has no \E inside. instead, it has \Q, \\, and E, so the result is the same as for "\\\\E". As a general rule, backslashes between \Q and \E may lead to counterintuitive results. So, "\Q\t\E" is converted to quotemeta("\t"), which is the same as "\\t" (since TAB is not alphanumeric).

Note also that:

```
$str = '\t';
return "\Q$str";
```

may be closer to the conjectural *intention* of the writer of "\Q\t\E".

Interpolated scalars and arrays are converted internally to the join and . catenation operations. Thus, "\$foo XXX '@arr'" becomes:

```
$foo . " XXX '" . (join $", @arr) . "'";
```

All operations above are performed simultaneously, left to right.

Because the result of "\Q STRING \E" has all metacharacters quoted, there is no way to insert a literal \$ or @ inside a \Q\E pair. If protected by \, \$ will be quoted to become "\\\\$"; if not, it is interpreted as the start of an interpolated scalar.

Note also that the interpolation code needs to make a decision on where the interpolated scalar ends. For instance, whether "a \$b -> {c}" really means:

```
"a " . $b . " -> {c}";
```

or:

```
"a " . $b -> {c};
```

Most of the time, the longest possible text that does not include spaces between components and which contains matching braces or brackets. because the outcome may be determined by voting based on heuristic estimators, the result is not strictly predictable. Fortunately, it's usually correct for ambiguous cases.

```
?RE?, /RE/, m/RE/, s/RE/fooo/,
```

Processing of `\Q`, `\U`, `\u`, `\L`, `\l`, and interpolation happens (almost) as with `qq//` constructs, but the substitution of `\` followed by RE-special chars (including `\`) is not performed. Moreover, inside `(?{BLOCK})`, `(?# comment)`, and a `#`-comment in a `//x`-regular expression, no processing is performed whatsoever. This is the first step at which the presence of the `//x` modifier is relevant.

Interpolation has several quirks: `$|`, `$(`, and `$)` are not interpolated, and constructs `$var[SOMETHING]` are voted (by several different estimators) to be either an array element or `$var` followed by an RE alternative. This is where the notation `/${arr[$bar]}` comes handy: `/${arr[0-9]}` is interpreted as array element `-9`, not as a regular expression from the variable `$arr` followed by a digit, which would be the interpretation of `/${arr[0-9]}`. Since voting among different estimators may occur, the result is not predictable.

It is at this step that `\1` is begrudgingly converted to `$1` in the replacement text of `s///` to correct the incorrigible *sed* hackers who haven't picked up the saner idiom yet. A warning is emitted if the `use warnings` pragma or the `-w` command-line flag (that is, the `$^W` variable) was set.

The lack of processing of `\\` creates specific restrictions on the post-processed text. If the delimiter is `/`, one cannot get the combination `\/` into the result of this step. `/` will finish the regular expression, `\/` will be stripped to `/` on the previous step, and `\\/` will be left as is. Because `/` is equivalent to `\/` inside a regular expression, this does not matter unless the delimiter happens to be character special to the RE engine, such as in `s*foo*bar*`, `m[foo]`, or `?foo?`; or an alphanumeric char, as in:

```
m m ^ a \s* b m m x;
```

In the RE above, which is intentionally obfuscated for illustration, the delimiter is `m`, the modifier is `m x`, and after backslash-removal the RE is the same as for `m/ ^ a \s* b /m x`. There's more than one reason you're encouraged to restrict your delimiters to non-alphanumeric, non-whitespace choices.

This step is the last one for all constructs except regular expressions, which are processed further.

Interpolation of regular expressions

Previous steps were performed during the compilation of Perl code, but this one happens at run time--although it may be optimized to be calculated at compile time if appropriate. After preprocessing described above, and possibly after evaluation if catenation, joining, casing translation, or metaquoting are involved, the resulting *string* is passed to the RE engine for compilation.

Whatever happens in the RE engine might be better discussed in *perlre*, but for the sake of continuity, we shall do so here.

This is another step where the presence of the `//x` modifier is relevant. The RE engine scans the string from left to right and converts it to a finite automaton.

Backslashed characters are either replaced with corresponding literal strings (as with `\{`), or else they generate special nodes in the finite automaton (as with `\b`). Characters special to the RE engine (such as `|`) generate corresponding nodes or groups of nodes. `(?#...)`

comments are ignored. All the rest is either converted to literal strings to match, or else is ignored (as is whitespace and #-style comments if `//x` is present).

Parsing of the bracketed character class construct, `[...]`, is rather different than the rule used for the rest of the pattern. The terminator of this construct is found using the same rules as for finding the terminator of a `{}`-delimited construct, the only exception being that `]` immediately following `[` is treated as though preceded by a backslash. Similarly, the terminator of `(?...)` is found using the same rules as for finding the terminator of a `{}`-delimited construct.

It is possible to inspect both the string given to RE engine and the resulting finite automaton. See the arguments `debug/debugcolor` in the `use re` pragma, as well as Perl's **-Dr** command-line switch documented in "*Command Switches*" in `perlrun`.

Optimization of regular expressions

This step is listed for completeness only. Since it does not change semantics, details of this step are not documented and are subject to change without notice. This step is performed over the finite automaton that was generated during the previous pass.

It is at this stage that `split()` silently optimizes `/^/` to mean `/^/m`.

I/O Operators

There are several I/O operators you should know about.

A string enclosed by backticks (grave accents) first undergoes double-quote interpolation. It is then interpreted as an external command, and the output of that command is the value of the backtick string, like in a shell. In scalar context, a single string consisting of all output is returned. In list context, a list of values is returned, one per line of output. (You can set `$/` to use a different line terminator.) The command is executed each time the pseudo-literal is evaluated. The status value of the command is returned in `$?` (see *perlvar* for the interpretation of `$?`). Unlike in **cs**h, no translation is done on the return data--newlines remain newlines. Unlike in any of the shells, single quotes do not hide variable names in the command from interpretation. To pass a literal dollar-sign through to the shell you need to hide it with a backslash. The generalized form of backticks is `qx//`. (Because backticks always undergo shell expansion as well, see *perlsec* for security concerns.)

In scalar context, evaluating a filehandle in angle brackets yields the next line from that file (the newline, if any, included), or `undef` at end-of-file or on error. When `$/` is set to `undef` (sometimes known as file-slurp mode) and the file is empty, it returns `' '` the first time, followed by `undef` subsequently.

Ordinarily you must assign the returned value to a variable, but there is one situation where an automatic assignment happens. If and only if the input symbol is the only thing inside the conditional of a `while` statement (even if disguised as a `for(;;)` loop), the value is automatically assigned to the global variable `$_`, destroying whatever was there previously. (This may seem like an odd thing to you, but you'll use the construct in almost every Perl script you write.) The `$_` variable is not implicitly localized. You'll have to put a `local $_;` before the loop if you want that to happen.

The following lines are equivalent:

```
while (defined($_ = <STDIN>)) { print; }
while ($_ = <STDIN>) { print; }
while (<STDIN>) { print; }
for (;<STDIN>;) { print; }
print while defined($_ = <STDIN>);
print while ($_ = <STDIN>);
print while <STDIN>;
```

This also behaves similarly, but avoids `$_`:

```
while (my $line = <STDIN>) { print $line }
```

In these loop constructs, the assigned value (whether assignment is automatic or explicit) is then tested to see whether it is defined. The defined test avoids problems where line has a string value that would be treated as false by Perl, for example a "" or a "0" with no trailing newline. If you really mean for such values to terminate the loop, they should be tested for explicitly:

```
while (($_ = <STDIN>) ne '0') { ... }
while (<STDIN>) { last unless $_; ... }
```

In other boolean contexts, `<filehandle>` without an explicit defined test or comparison elicit a warning if the `use warnings` pragma or the `-w` command-line switch (the `$^W` variable) is in effect.

The filehandles `STDIN`, `STDOUT`, and `STDERR` are predefined. (The filehandles `stdin`, `stdout`, and `stderr` will also work except in packages, where they would be interpreted as local identifiers rather than global.) Additional filehandles may be created with the `open()` function, amongst others. See *perlopentut* and *"open" in perlfunc* for details on this.

If a `<FILEHANDLE>` is used in a context that is looking for a list, a list comprising all input lines is returned, one line per list element. It's easy to grow to a rather large data space this way, so use with care.

`<FILEHANDLE>` may also be spelled `readline(*FILEHANDLE)`. See *"readline" in perlfunc*.

The null filehandle `<>` is special: it can be used to emulate the behavior of **sed** and **awk**. Input from `<>` comes either from standard input, or from each file listed on the command line. Here's how it works: the first time `<>` is evaluated, the `@ARGV` array is checked, and if it is empty, `$ARGV[0]` is set to "-", which when opened gives you standard input. The `@ARGV` array is then processed as a list of filenames. The loop

```
while (<>) {
... # code for each line
}
```

is equivalent to the following Perl-like pseudo code:

```
unshift(@ARGV, '-') unless @ARGV;
while ($ARGV = shift) {
open(ARGV, $ARGV);
while (<ARGV>) {
... # code for each line
}
}
```

except that it isn't so cumbersome to say, and will actually work. It really does shift the `@ARGV` array and put the current filename into the `$ARGV` variable. It also uses filehandle `ARGV` internally--`<>` is just a synonym for `<ARGV>`, which is magical. (The pseudo code above doesn't work because it treats `<ARGV>` as non-magical.)

You can modify `@ARGV` before the first `<>` as long as the array ends up containing the list of filenames you really want. Line numbers (`$.`) continue as though the input were one big happy file. See the example in *"eof" in perlfunc* for how to reset line numbers on each file.

If you want to set `@ARGV` to your own list of files, go right ahead. This sets `@ARGV` to all plain text files if no `@ARGV` was given:

```
@ARGV = grep { -f && -T } glob('*') unless @ARGV;
```

You can even set them to pipe commands. For example, this automatically filters compressed arguments through **gzip**:

```
@ARGV = map { /\. (gz|Z)$ / ? "gzip -dc < $_ |" : $_ } @ARGV;
```

If you want to pass switches into your script, you can use one of the `Getopts` modules or put a loop on the front like this:

```
while ($_ = $ARGV[0], /^-/) {
  shift;
  last if /^--$/;
  if (/^-D(.*)/) { $debug = $1 }
  if (/^-v/)      { $verbose++ }
  # ... # other switches
}

while (<>) {
  # ... # code for each line
}
```

The `<>` symbol will return `undef` for end-of-file only once. If you call it again after this, it will assume you are processing another `@ARGV` list, and if you haven't set `@ARGV`, will read input from `STDIN`.

If what the angle brackets contain is a simple scalar variable (e.g., `<$foo>`), then that variable contains the name of the filehandle to input from, or its `typeglob`, or a reference to the same. For example:

```
$fh = \*STDIN;
$line = <$fh>;
```

If what's within the angle brackets is neither a filehandle nor a simple scalar variable containing a filehandle name, `typeglob`, or `typeglob` reference, it is interpreted as a filename pattern to be globbed, and either a list of filenames or the next filename in the list is returned, depending on context. This distinction is determined on syntactic grounds alone. That means `<$x>` is always a `readline()` from an indirect handle, but `<$hash{key}>` is always a `glob()`. That's because `$x` is a simple scalar variable, but `$hash{key}` is not—it's a hash element. Even `<$x >` (note the extra space) is treated as `glob("$x ")`, not `readline($x)`.

One level of double-quote interpretation is done first, but you can't say `<$foo>` because that's an indirect filehandle as explained in the previous paragraph. (In older versions of Perl, programmers would insert curly brackets to force interpretation as a filename glob: `<${foo}>`. These days, it's considered cleaner to call the internal function directly as `glob($foo)`, which is probably the right way to have done it in the first place.) For example:

```
while (<*.c>) {
  chmod 0644, $_;
}
```

is roughly equivalent to:

```
open(FOO, "echo *.c | tr -s ' \t\r\f' '\\012\\012\\012\\012'|");
while (<FOO>) {
  chomp;
  chmod 0644, $_;
}
```

except that the globbing is actually done internally using the standard `File::Glob` extension. Of course, the shortest way to do the above is:

```
chmod 0644, <*.c>;
```

A (file)glob evaluates its (embedded) argument only when it is starting a new list. All values must be read before it will start over. In list context, this isn't important because you automatically get them all anyway. However, in scalar context the operator returns the next value each time it's called, or `undef` when the list has run out. As with filehandle reads, an automatic `defined` is generated when the glob occurs in the test part of a `while`, because legal glob returns (e.g. a file called `0`) would otherwise terminate the loop. Again, `undef` is returned only once. So if you're expecting a single value from a glob, it is much better to say

```
($file) = <blurch*>;
```

than

```
$file = <blurch*>;
```

because the latter will alternate between returning a filename and returning false.

If you're trying to do variable interpolation, it's definitely better to use the `glob()` function, because the older notation can cause people to become confused with the indirect filehandle notation.

```
@files = glob("$dir/*. [ch]");  
@files = glob($files[$i]);
```

Constant Folding

Like C, Perl does a certain amount of expression evaluation at compile time whenever it determines that all arguments to an operator are static and have no side effects. In particular, string concatenation happens at compile time between literals that don't do variable substitution. Backslash interpolation also happens at compile time. You can say

```
'Now is the time for all' . "\n" .  
'good men to come to.'
```

and this all reduces to one string internally. Likewise, if you say

```
foreach $file (@filenames) {  
  if (-s $file > 5 + 100 * 2**16) { }  
}
```

the compiler will precompute the number which that expression represents so that the interpreter won't have to.

No-ops

Perl doesn't officially have a no-op operator, but the bare constants `0` and `1` are special-cased to not produce a warning in a void context, so you can for example safely do

```
1 while foo();
```

Bitwise String Operators

Bitstrings of any size may be manipulated by the bitwise operators (`~` | `&` `^`).

If the operands to a binary bitwise op are strings of different sizes, `|` and `^` ops act as though the shorter operand had additional zero bits on the right, while the `&` op acts as though the longer operand were truncated to the length of the shorter. The granularity for such extension or truncation is one or more bytes.

```
# ASCII-based examples
print "j p \n" ^ " a h";          # prints "JAPH\n"
print "JA" | " ph\n";            # prints "japh\n"
print "japh\nJunk" & '_____';  # prints "JAPH\n"
print 'p N$' ^ " E<H\n";         # prints "Perl\n";
```

If you are intending to manipulate bitstrings, be certain that you're supplying bitstrings: If an operand is a number, that will imply a **numeric** bitwise operation. You may explicitly show which type of operation you intend by using `" "` or `0+`, as in the examples below.

```
$foo = 150 | 105; # yields 255 (0x96 | 0x69 is 0xFF)
$foo = '150' | 105; # yields 255
$foo = 150 | '105'; # yields 255
$foo = '150' | '105'; # yields string '155' (under ASCII)

$baz = 0+$foo & 0+$bar; # both ops explicitly numeric
$biz = "$foo" ^ "$bar"; # both ops explicitly stringy
```

See *"vec" in perlfunc* for information on how to manipulate individual bits in a bit vector.

Integer Arithmetic

By default, Perl assumes that it must do most of its arithmetic in floating point. But by saying

```
use integer;
```

you may tell the compiler that it's okay to use integer operations (if it feels like it) from here to the end of the enclosing BLOCK. An inner BLOCK may countermand this by saying

```
no integer;
```

which lasts until the end of that BLOCK. Note that this doesn't mean everything is only an integer, merely that Perl may use integer operations if it is so inclined. For example, even under `use integer`, if you take the `sqrt(2)`, you'll still get 1.4142135623731 or so.

Used on numbers, the bitwise operators ("`&`", "`|`", "`^`", "`~`", "`<<`", and "`>>`") always produce integral results. (But see also *Bitwise String Operators*.) However, `use integer` still has meaning for them. By default, their results are interpreted as unsigned integers, but if `use integer` is in effect, their results are interpreted as signed integers. For example, `~0` usually evaluates to a large integral value. However, `use integer; ~0` is `-1` on twos-complement machines.

Floating-point Arithmetic

While `use integer` provides integer-only arithmetic, there is no analogous mechanism to provide automatic rounding or truncation to a certain number of decimal places. For rounding to a certain number of digits, `sprintf()` or `printf()` is usually the easiest route. See *perlfaq4*.

Floating-point numbers are only approximations to what a mathematician would call real numbers. There are infinitely more reals than floats, so some corners must be cut. For example:

```
printf "%.20g\n", 123456789123456789;
#           produces 123456789123456784
```

Testing for exact equality of floating-point equality or inequality is not a good idea. Here's a (relatively expensive) work-around to compare whether two floating-point numbers are equal to a particular number of decimal places. See Knuth, volume II, for a more robust treatment of this topic.

```
sub fp_equal {
```

```
my ($X, $Y, $POINTS) = @_;
my ($tX, $tY);
$tX = sprintf("%.${POINTS}g", $X);
$tY = sprintf("%.${POINTS}g", $Y);
return $tX eq $tY;
}
```

The POSIX module (part of the standard perl distribution) implements `ceil()`, `floor()`, and other mathematical and trigonometric functions. The `Math::Complex` module (part of the standard perl distribution) defines mathematical functions that work on both the reals and the imaginary numbers. `Math::Complex` not as efficient as POSIX, but POSIX can't work with complex numbers.

Rounding in financial applications can have serious implications, and the rounding method used should be specified precisely. In these cases, it probably pays not to trust whichever system rounding is being used by Perl, but to instead implement the rounding function you need yourself.

Bigger Numbers

The standard `Math::BigInt` and `Math::BigFloat` modules provide variable-precision arithmetic and overloaded operators, although they're currently pretty slow. At the cost of some space and considerable speed, they avoid the normal pitfalls associated with limited-precision representations.

```
use Math::BigInt;
$x = Math::BigInt->new('123456789123456789');
print $x * $x;

# prints +15241578780673678515622620750190521
```

There are several modules that let you calculate with (bound only by memory and cpu-time) unlimited or fixed precision. There are also some non-standard modules that provide faster implementations via external C libraries.

Here is a short, but incomplete summary:

```
Math::Fraction  big, unlimited fractions like 9973 / 12967
Math::String    treat string sequences like numbers
Math::FixedPrecision  calculate with a fixed precision
Math::Currency  for currency calculations
Bit::Vector     manipulate bit vectors fast (uses C)
Math::BigIntFast  Bit::Vector wrapper for big numbers
Math::Pari      provides access to the Pari C library
Math::BigInteger  uses an external C library
Math::Cephes    uses external Cephes C library (no big numbers)
Math::Cephes::Fraction  fractions via the Cephes library
Math::GMP       another one using an external C library
```

Choose wisely.