Introduction to Perl

Texas A&M High Performance Research Computing (HPRC)

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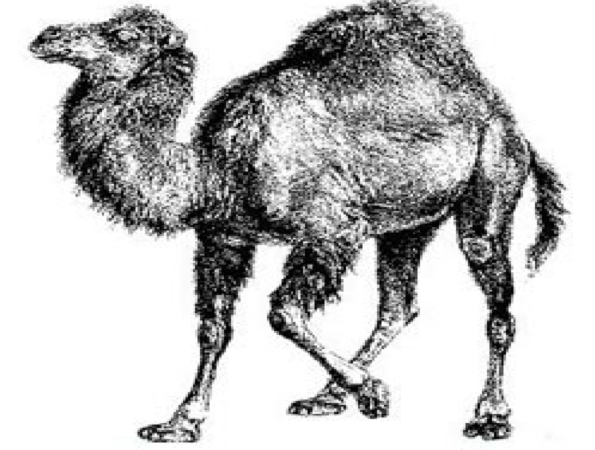


Acknowledgements

- Title page clip art taken from O'Reilly Publishers books *Programming Perl*.
- A few code examples taken from *Programming Perl* and *Beginning Perl for Bioinformatics*, as well as on-line references.
  (See `hprc.tamu.edu`)
- **`perlconsole`** was written by Alexis Sukrieh
  (See `http://sukria.net/perlconsole.html`)

Who Should Attend This Class?

HPRC users who need the power and simplicity of Perl to do:

- Text and pattern analysis
- File administration
- Database and network operations
- Quick, easy Unix tasks

Upcoming HPRC Short Courses

https://hprc.tamu.edu/training/

Thu, Oct 5	Viz Portal: Abaqus NEW
Tue, Oct 10	Intro to MATLAB Parallel Toolbox
Wed, Oct 11	Intro to Next Generation Sequencing
Thu, Oct 12	Viz Portal: Paraview NEW
Tue, Oct 17	Introduction to Code Parallelization using OpenMP

Suggested Prerequisites

- **HPRC account**
  (See `https://hprc.tamu.edu/apply/`)
- **Intro to Unix shortcourse**
  (`https://hprc.tamu.edu/training/intro_unix.html`)
- **Experience with programming at least one language** (C, C++, FORTRAN, Java, or similar)

Agenda

- What kind of language is Perl?
- Executing your program
- Finding documentation
- Statement syntax
- Variables, constants, expressions
- Control Flow
- Error messages
- I/O

What is Perl?

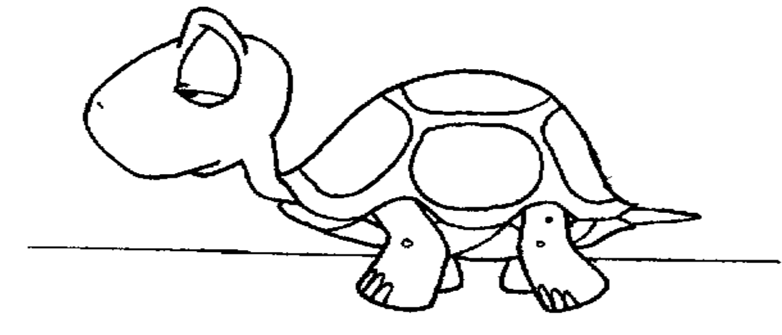
1. Interpreted, dynamic programming language
2. High-level language
   - Functional
   - Procedural
   - Object-oriented
3. Extensible library modules

What Perl Does Well

1. Pattern matching with regular expressions
2. String processing
3. Hash tables
4. File I/O
5. Network and database access
6. CGI (website)

Limitations of Perl

1. Compiled on each run
2. Large FP calculations not as fast or as easy as FORTRAN or C/C++
3. No contiguous multi-dimensional arrays. Complex data structures have memory management overhead



How to Run a Perl Program

Usually, program is in a file with "**.pl**" suffix. You can run it from the command line with the **perl** command:

```
$ perl sum.pl
```

Run Perl with **–e**

You can run short programs with **–e** option:

```
$ perl –e 'printf("%f\n", exp(10 * log(2)))'
```

Be sure to put quotes around your statements so they are passed unchanged to **perl**.

Run with **eval perl**

You can use **eval perl** to enter statements without creating a file:

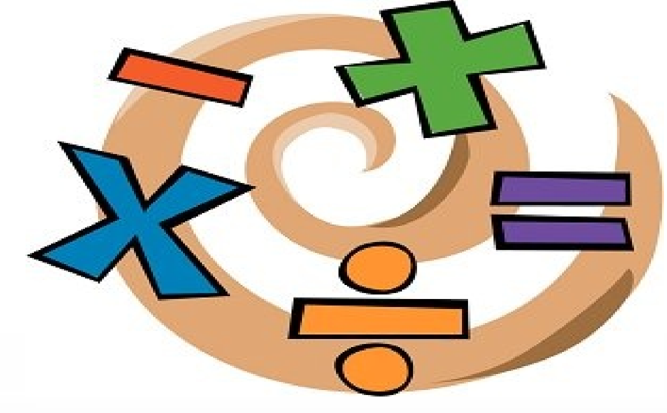
```
$ eval perl
$x = 3;
$y = 8;
printf("The sum is %d\n", $x + $y);
```

Press ctrl-d (^D) on a new line to complete input.

Testing with **`eval perl`**

Using **`eval perl`** allows you to quickly test Perl syntax without a program file.

```
$ eval perl
@a = ('red', 'green', 'blue');
print @a, "\n";
print @a . "\n";
print "@a\n";
```



Testing with **perlconsole**

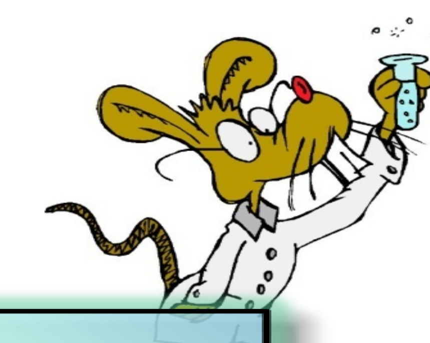
perlconsole allows you to run Perl statements interactively for quick testing.

- Not a standard utility.

```
ada$ /scratch/training/Perl/bin/perlconsole
Perl Console 0.4
Perl> printf "sum is %d\n", 8 + 9;
```

Configuring **perlconsole**

- For informative output, create **$HOME/.perlconsolerc** :



```
$ echo ":set output=dumper" > ~/.perlconsolerc
```

On-Line Documentation

1. Unix man pages:

```
$ man perl
$ man perlfunc
```

2. Websites, such as:
   http://perldoc.perl.org

Perl Books

hprc.tamu.edu

The Perl Programming Language

http://www.perl.org

Variable Names

Names in Perl:

- Start with a letter
- Contain letters, numbers, and underscores "_"
- Case sensitive

Two major types:

`$` Scalars (single value)

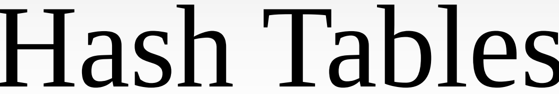
`@` Lists

Scalars

- Start with a dollar sign “$”
- Can be of type:
  - Integer
  - Floating point
  - String
  - Binary data
  - Reference (like a pointer)
- But Perl is not a strongly typed language

Lists

- Start with an at symbol “@”
- Also known as arrays
- Always one-dimensional
- Index starts at 0
- Can contain mixture of scalar types (not strongly typed)



- Start with percent sign “%”
- Implemented as a list with special properties
- Key-Value pairs
- Keys are unique
- Keys can be any scalar value
- Values can be any scalar value

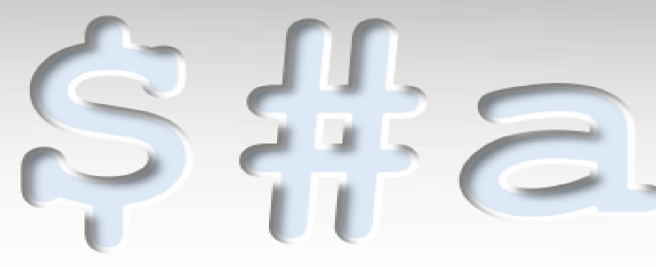
List Elements

- Individual array elements:
  - Scalar values
  - Start with "$"
  - Indexed in square brackets: "[ ]"

```
@a = (2, 3, 5, 7, 11);
print $a[3];
$a[5] = 13;
```

prints "7"

extends @a by one



List Size

- Assign array to scalar to get list length
- The top index is given by "**$#**"

```
@a = (2, 3, 5, 7, 11);
$len = @a;
$len = $#a + 1;
```

$len gets "5"
Same thing

Hash Elements

- Individual array elements:
  - Scalar values
  - Start with “$”
  - Indexed in curly brackets: “{ }”

```
%h = (name => "Sam", phone => "555-1212");
print $h{name};
$h{age} = 27;
```

prints “Sam”

extends %h by one

Same Name, Different Variables

- The same name can be reused for scalars, arrays, hashes, subroutine names, file handles, etc..
- Each of the following refer to a completely different thing:

Perl Statement Syntax

- Statements separated by semicolons: “;”
- Statement blocks surrounded by curly braces: “{ }”
- Comments preceded by pound sign: “#”

Sample Syntax

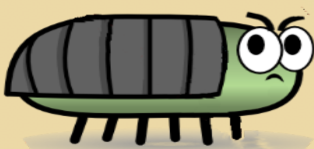
```
# see if we need to run work()
$remaining = queue_size();
if ($remaining > 0)
{
    work($x);          # does the main task
    print "did work\n";
}
```

Common Syntax Errors

```
if ($remaining > 0)
    work($x);

for ($i = 1; $i < $n; $i++)
    print a[$i], "\n";

while ($c = 1)
{
    $c = do_thing($m, $q);
}
```



Fixing Errors

```
if ($remaining > 0)
{    work($x);    }

for ($i = 1; $i < $n; $i++)
{    print $a[$i], "\n";    }

while ($c == 1)
{
    $c = do_thing($m, $q);
}
```

Perl Control Statements

- Conditionals:
  - **`if/elsif/else`**
  - **`unless`** *(inverse of "**if**")*
  - Experimental statements **`given/when`** (like "**`switch/case`**")
- Loops:

`for(;;)`	**`foreach ()`**	**`while()`**
`until()`	**`do()`**	

Common Perl Statements

- Assignment (use equal sign: “=”)
- Jumping
  - **`next/last/redo/goto`**
- Subroutine calls
  - Functional
  - Procedural
  - Object method
- Print statements

Assignments

- Use a single equal sign: “=”
- Put the value on the right into the place specified on the left

variable ← value

- Left-hand side of assignment called the “L-value”, most often a variable

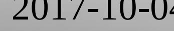
Assignment Examples

```
$a = 2.75;           # scalar, floating point

$color = 'yellow';   # scalar, string

# array of four strings
@ary = ( "Perl", "C++", "Java", "FORTRAN" );

# hash, two keys (strings), numeric values
%ht = ( "AAPL" => 282.52, "MSFT" => 24.38 );
```

Assigning List Elements

```
@ary = ( "Perl", "C", "Java", "FORTRAN" );

$ary[1] = "C++";    # overwrite "C"

%ht = ( "AAPL" => 282.52, "MSFT" => 24.38 );

$ht{IBM} = 135.64; # add 1 item to hash
```

Operator-Assignment

```
$a += 10;             # add 10 to $a
$b *= 2.5;            # multiply $b by 2.5

$name .= ', Jr.';  # append to $name

$mode &= 0722; # apply bitwise mask to $mode
```

Scalar Values

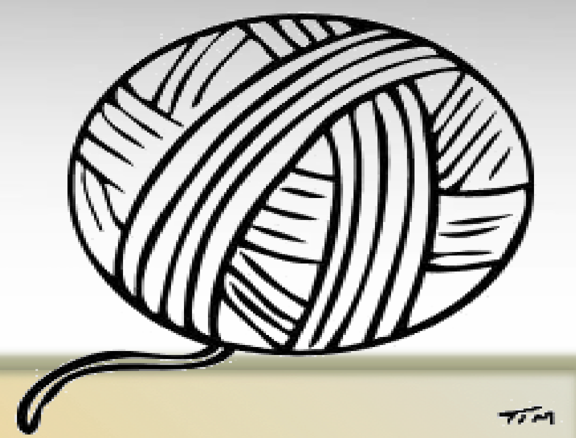
Scalar expression can be numeric or string, made from any of:

Variable	`$a`	`$ht{MSFT}`
Constant	`2.6`	`'blue'`
Function	`sin($angle)`	`length($name)`
Operators	`$a/sin($ang)+ 2.6`	`$col . "_" . $sz`

Numeric Constants

```
10        # decimal integer
0722      # octal integer
0xF3E9    # hexadecimal integer
-2.532    # floating point
6.022E23 # floating point (scientific)
```

String Constants



```
'simple'         # single quotes

"one\ttwo"       # double quotes

<<"END_TEXT";    # here document (dbl quotes)
1\t15kg\t3:25
2\t9kg\t0:22
END_TEXT
```

List Forms

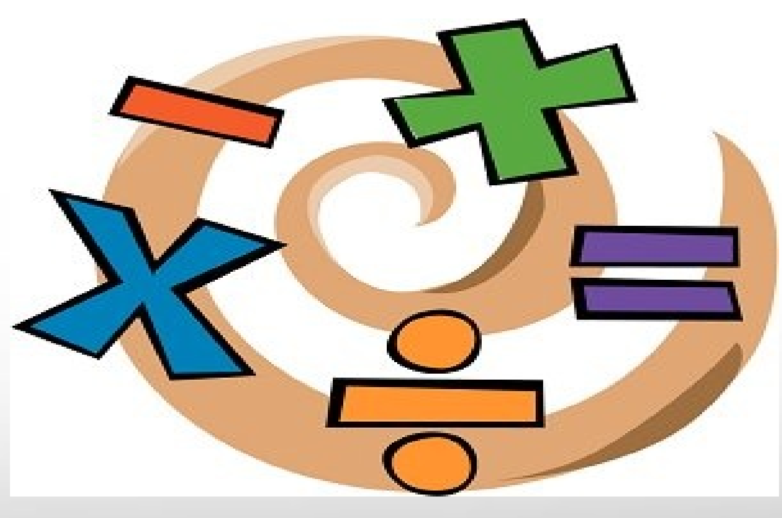
```
("one", "two", 3) # list of mixed constants

qw(one two 3)     # same thing

# hash table
(
    "Mustang" => "Ford",
    "Civic"   => "Honda",
)
```

Operators

- Numeric operators are mostly the same as C/C++, also the "**" (exponent) operator
- Also has string and regular expression operators
- Documentation:
  - http://perldoc.perl.org/perlop.html
  - "**man perlop**"



Numeric Operators

```
$x + 3        -4.3 / $z        2 ** 10

$i++          --$j             $f % $mod
```

Bitwise Operators

```
$mode << 8        $t | 0x3F

$v ^ $mask        ~$q
```

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Comparison Operators

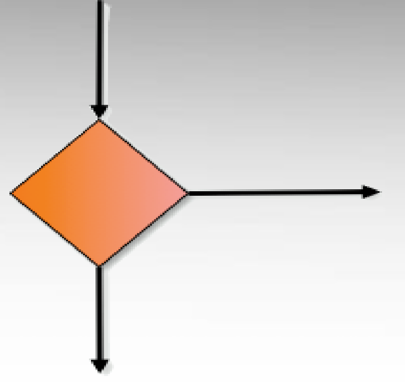
```
# numeric
$x == 3       $a >= -4.3       $m != $n

# stringwise
$y eq "AT"    $title lt 'm'    $q ne 'B'
```

Sort Comparison Operators

-1	Left is less than right
0	Left equals right
+1	Left is greater than right

```
# numeric       stringwise
$x <=> $y       $s cmp $t
```

Logical Operators



Logical Operators

```
# C-style
$ready && ($y > 2)    !$done     $e || $r

# lower precedence
$ready and $y > 2    not $done    $e or $r

# ternary conditional
($d != 0) ? ($n / $d) : "Inf"
```

Comparison Operators

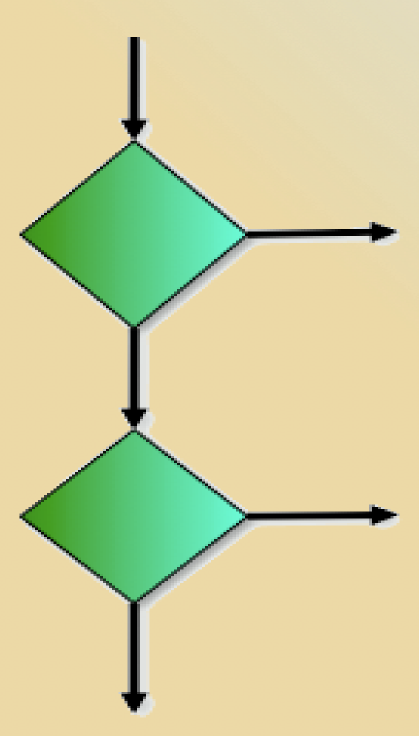
```
# numeric
$x == 3         $a >= -4.3         $m != $n

# stringwise
$y eq "AT"      $title lt 'm'      $q ne 'B'
```

Other Operators

```
# List separators
2, 4, 6     "R" => 255, "G" => 0, "B" => 127

# string concatenation
"First " . $item

# string repetition
"AB" x 10

# range operator
1..10        0..$#ary
```

Conditional Branches

```
# choose the size of x
if ($x > 5) {
    print "big x\n";
} elsif ($x > 3) {
    print "medium x\n";
} else {
    print "small x\n";
}
```



Conditional After Statement

```
print "f is even\n" if ($f % 2 == 0);

print "not capitalized\n"
    unless ($name =~ /^[A-Z]/);
```

- Special feature of Perl
- Avoids need for braces
- Can be confusing and no “else” branch

Logical Operator as Conditional

```
($y != 0) &&                # C-style
    $ratio = $x / $y;

(-f $myfile) or             # word style
    die "File ``$myfile'' does not exist!";
```

- Avoids need for braces
- Can be confusing and no “else”
- Word style better rather than C-style

While Loops

```
$x = 1;                     # initialize
while ($x != 7) {           # test
    print "x = $x\n";
    $x += 2;
    last if ($x > 12); # escape clause
}
```

For Loops

```
for ($x = 1; $x != 7; $x += 2) {
    print "x = $x\n";
    last if ($x > 12); # escape clause
}
```

Foreach Loops

```
foreach $index (0..$#myarray) {
    $item = $myarray[$index];
    printf "cost of %s is \$%1.2f\n",
        $item, $price{$item};
    print "TOO MUCH!\n"
        if ($price{$item} > 1200);
}
```

Errors and Warnings

- Warning is “non-fatal”, can still keep going
- Error can be at:
  - Compile time, e.g., syntax errors
  - Run time:
    - Numeric, e.g., division by zero
    - Reference type, e.g., hash vs. List
    - Object method

Warnings

Using -w option turns on warning messages

```
$ perl -w bounds.pl
Use of uninitialized value in addition (+) at bounds.pl line
8.
b = 3
```

Warnings Pragma

Put "**`use warnings`**" pragma at top to turn on warning messages.

```
use warnings;

my @a = (1, 2);
my $b = $a[0] + $a[1] + $a[2];

print "b = $b\n";
```

Uninitialized Value

```
my @a = (1, 2);
my $b = $a[0] + $a[1] + $a[2];
```

```
$ ./bounds.pl
Use of uninitialized value in addition (+) at ./bounds.pl
line 8.
```

“should be ==”

```
print "c is big\n" if ($c = 100);
```

```
$ ./twoeq.pl
Found = in conditional, should be == at ./twoeq.pl line 8.
```

Syntax Errors

```
while a < 10 {
```

```
$ ./synerr.pl
syntax error at ./synerr.pl line 4, near "while a "
syntax error at ./synerr.pl line 8, near "}"
Execution of ./synerr.pl aborted due to compilation errors.
```

Runaway Strings

```
$ ./closeq.pl
Scalar found where operator expected at ./closeq.pl line 8, near "print "$a"
  (Might be a runaway multi-line "" string starting on line 3)
        (Do you need to predeclare print?)
Backslash found where operator expected at ./closeq.pl line 8, near "$a\"
        (Missing operator before \?)
String found where operator expected at ./closeq.pl line 8, at end of line
        (Missing semicolon on previous line?)
syntax error at ./closeq.pl line 8, near "print "$a"
Can't find string terminator '"' anywhere before EOF at ./closeq.pl line 8.
```

Checking for Errors

Do your own error checking, to get diagnostics:

```
die "denominator zero " if ($d == 0);
$r = $n / $d;
```

- The “die” and “warn” functions output to stderr and can show line number
- The “Carp” module is more detailed

System Error String

If a system call fails, look at "**$!**" variable

```
open FH, $myfile, "r" or
    die "open $myfile: $! ";
```

```
$ ./nofile.pl
open nofile: No such file or directory  at
./nofile.pl line 4.
```

Perl Debugger

You can use **`perl -d`** to debug your program:

```
$ perl –d debugme.pl
$Loading DB routines from perl5db.pl version 1.28

Enter h or `h h' for help, or `man perldebug' for more help.

main::(debugme.pl:7):   my @a = qw(TAGC CGTA ATTT GGCA);
DB<1>
```

Variable Scope

- Using the "**`my`**" declaration makes a variable local to the statement block or file.
- Don't use "**`local`**" declaration unless you understand it—the "**`my`**" declaration is almost always what you want.
- The "**`our`**" declaration is used for declaring global variables within packages (modules).

Examples of Local Variables

- Surround multiple declared variables with parentheses.

```
my $a;
my @f;
my $x = "initial value";
my ($i, $j, $k);
foreach my $item (@ilist) {
    $sum += $item;
}
```

Example of Scope

```
my @numlist = (3, 4, 5);

foreach my $item (@numlist) {
    print "item = $item\n";
}
print "item = $item\n”;
```

```
item = 3
item = 4
item = 5
item =
```

Strict Pragma

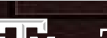
Put "**`use strict`**" pragma at top to require use of "**`my`**" declarations.

```
use strict;

my $x = 15;
$y = 19;

print ”y = $y\n";
```

Input/Output

File Handles

- **`STDIN`**, **`STDOUT`**, and **`STDERR`** correspond to the **`stdin`**, **`stdout`**, and **`stderr`** of C/C++.
- A simple Perl filehandle is a name by itself, typically all caps.
- Filehandles can be scalar variables, too.
- Objects from **`IO::File`** and similar library modules have advantages.



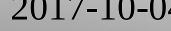
Printing

- **`print`**
  - Prints a list of strings
- **`printf`**
  - C-style formatting
- **`syswrite`**
  - Low-level **`write(2)`** system call
  - Unbuffered and unformatted.

File Handle in Printing

- **print *FH LIST***
- **printf *FH FORMAT*, *LIST***
- **syswrite *FH*, *DATA*, ...**

For **print** and **printf** there is no comma separating file handle from arguments. Without a file handle, the output goes to **STDOUT**, by default.



Print Examples

```
print "Hello, world!\n";
print STDOUT "Hello, world!\n"; # same

print STDERR "File not found:", $fname,
   "\n";


printf MYRPT "%d items processed\n",
    $count;
printf MYRPT ("%d items processed\n",
    $count);                         # same
```

Reading

- **`< >`**
  - Input operator for buffered input.
  - Uses **`STDIN`**, by default.
- **`< FH >`**
  - Input from filehandle ***`FH`***.
- **`sysread`**
  - Low-level **`read(2)`** system call
  - Unbuffered and unformatted.

Input Examples

```
print ”Enter name:";
$name = <>;

@listing = <STDIN>; # read all lines

# one line at a time
while ($line = <$myinfo>) {
    myprocess($line);
}
```

Opening a File

- The **open** function opens a file for reading, writing, appending, or more.
- Can specify a bareword file handle name or a scalar variable.

```
open(MYINFO, "<info.dat") or
    die("open info.dat: $! ");

open $fh, ">logfile" or die $!;
```

File Mode

Read	<	+<
Create/truncate	>	+>
Append	>>	+>>

```
open(MYINFO, ”+<info.dat") or
    die("open info.dat: $! ");

open $fh, $fname, ">>" or die $!;
```

Putting it Together

```
open RAW, $rfile, "<";
open $ofh, ">>results";

while ($line = <RAW>) {
    @useful = myprocess($line);
    printf $ofh "%d,%6.2f,%s\n", @useful;
}
```

Command Substitution

- A shorthand way to run a command an capture the output is with the backwards single quotes, or “**qx**”:

```
$hostname = `/bin/hostname`;
$hostname = qx{/bin/hostname};
```

Same thing