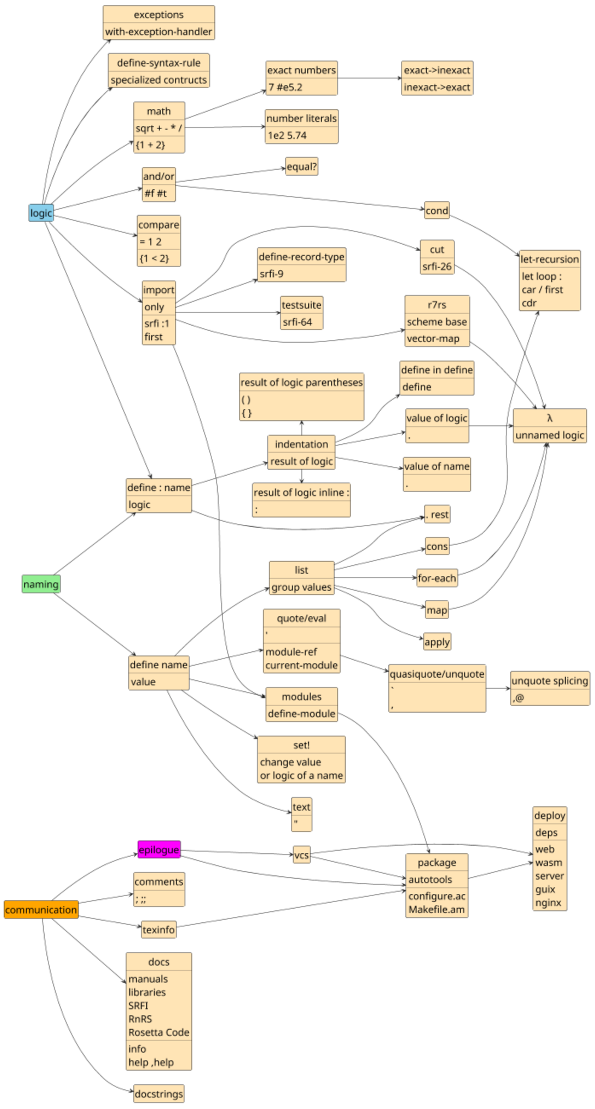
<2024-11-23 Sa> Dr. Arne Babenhauserheide / draketo.de

Naming and Logic

programming essentials with Wisp

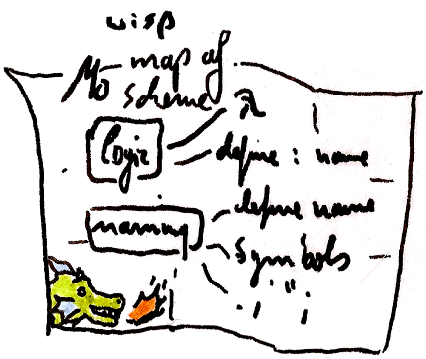
and a three-fold Zen for Scheme



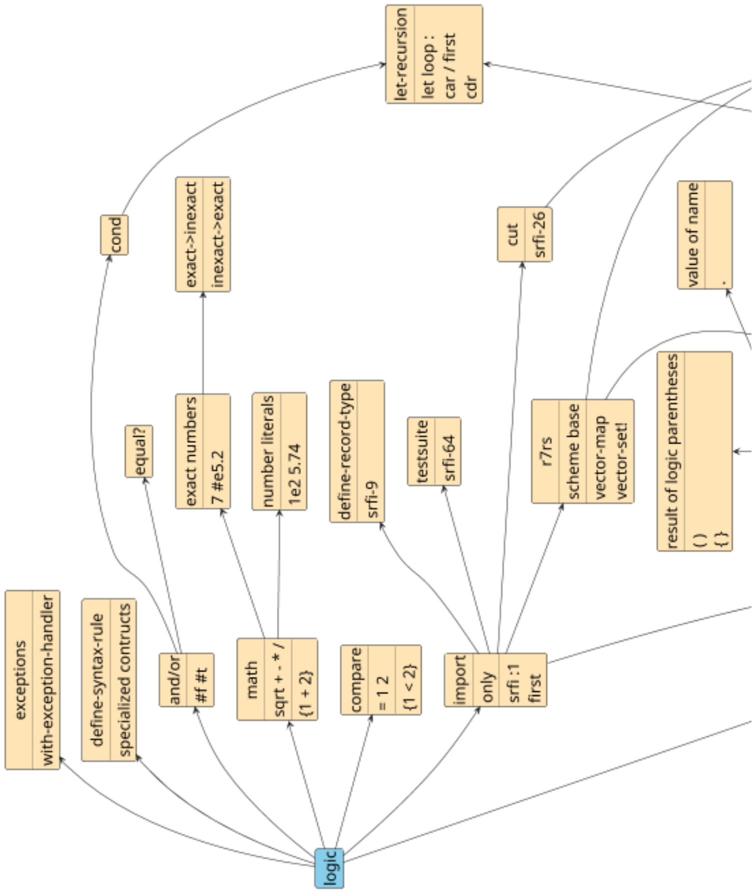
Find the heart of programming with the map of Scheme.

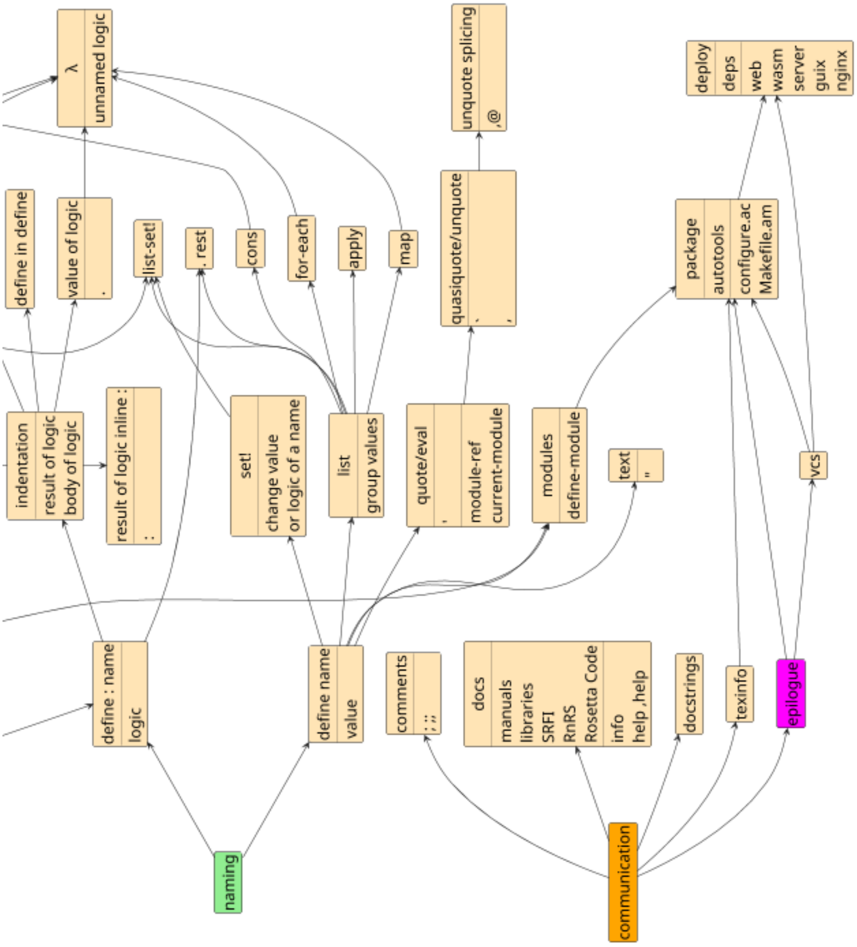
To follow along, install Wisp and try the examples as you read.

Best practices in Lisp with fewer parentheses.



i The Map of Scheme




naming
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ii Preface

Why this book? To provide a concise start, a no-frills, opinionated intro to programming from first `define` to deploying an application on just 64 short pages.

Who is it for? You are a newcomer and want to **learn by trying code examples**? You know programming and want **a running start** into Wisp or Scheme? You want to see how little suffices with Scheme's principle *"design not by piling feature on top of feature, but by* ***removing the weaknesses and restrictions*** *that make additional features appear necessary"*? Then this book is for you.

What is Wisp? Wisp is the simplest possible indentation based syntax which is able to express all possibilities of Lisp. It is included in Guile Scheme, the official extension language of the GNU project.

»best I've seen; pythonesque, hides parens but keeps power«
— Christine Webber, 2015

How to get Wisp? Download and install Wisp from the website `www.draketo.de/software/wisp` — then open the REPL by executing `wisp` in the terminal. The REPL is where you type and try code interactively. Or install `Guile 3.0.10+` and run `guile --language=wisp`. On some platforms you need to use `guile3.0 --language=wisp`.

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1 Name a value: define

Use define to name a value. Use . to return a value.

```
define small-tree-height-meters 3
define large-tree-height-meters 5
. small-tree-height-meters ;; returns the value 3
```

After typing or copying a block into the Wisp REPL, **hit enter three times**. You should then see

```
$1 = 3
```

This means: the first returned value (`$1`) is 3. The next time you return a value, it will be called `$2`.

Names can contain any letter except for (white-)space, quote, comma or parentheses. They must not be numbers.

```
define illegal name 1
define 'illegal-name 2
define ,illegal-name 3
define illegal)name 4
define 1113841 5
```

```
While compiling expression:
Syntax error:
unknown location: source expression failed to match any
 ↪  pattern in form (define illegal name 1)
While reading expression:
#<unknown port>:4:16: unexpected ")"
```

2 Compare numbers

```
= 3 5
```

```
$1 = #f
```

```
= 3 3
```

```
$1 = #t
```

`#t` means true, `#f` means false.

Returns the result of logic without needing a period (`.`).

The logic comes first. This is clear for `=`, but easy to misread for `<`.

```
< 3 5 ;; is 3 smaller than 5? #true
< 5 3 ;; is 5 smaller than 3? #false
> 3 5 ;; is 3 bigger than 5? #false
> 5 3 ;; is 5 bigger than 3? #true

> 3 3 ;; is 3 bigger than 3? #false
>= 3 3 ;; is 3 bigger or equal to 3? #true
<= 3 3 ;; is 3 smaller or equal to 3? #true
```

```
$1 = #t
$2 = #f
$3 = #f
$4 = #t
$5 = #f
$6 = #t
$7 = #t
```

3 Use infix in logic

```
. {3 = 5}
. {3 < 5}
. {3 > 5}
```

```
$1 = #f
$2 = #t
$3 = #f
```

Infix logic gives a value, so you need `.` to return it.

Because infix-logic gives a value, you can use it in place of a value.

For example to nest it:

```
. {{5 < 3} equal? #f}
```

```
$1 = #t
```

Or to name it as value:

```
define is-math-sane? {3 < 5}
. is-math-sane?
```

```
$1 = #t
```

By convention, names that have the value `true` or `false` have the suffix `?`.

4 Use named values in logic

```
define small-tree-height/m 3
define large-tree-height/m 5
. {small-tree-height/m < large-tree-height/m}
```

```
$1 = #t
```

5 Add comments with ;

```
define birch-height/m 3
;; this is a comment
define height ; comment at the end
  ;; comment between lines
  . birch-height/m
. height
```

```
$1 = 3
```

It is common to use `;;` instead of `;`, but not required.

6 Logic with true and false using `and` or `or`

```
and #t #t
and #f #t
or #f #t
or #f #f
```

```
$1 = #t
$2 = #f
$3 = #t
$4 = #f
```

If any value passed to `and` is `#f` (`#false`), it ignores further values. If any value passed to `or` is not `#f` (not `#false`), it ignores further values.

```
and #t #t #t ;; => #true
and #t #f #t ;; => #false
and {3 < 5} {5 < 3} ;; => #false
or #t #f #t ;; => true
or {3 < 5} {5 < 3} ;; => #true
or #f #f #f ;; => #false
```

```
$1 = #t
$2 = #f
$3 = #f
$4 = #t
$5 = #t
$6 = #f
```

For `and` and `or`, everything is `#true` (`#t`) except for `#false` (`#f`). Given the number of hard to trace errors in other languages that turn up in production, this is the only sane policy.

7 Name the result of logic with indentation

```
define birch-h/m 3
define chestnut-h/m 5
define same-héight?
  = birch-h/m chestnut-h/m
define smaller?
  . {birch-h/m < chestnut-h/m} ;; infix
. smaller?
```

```
$1 = #t
```

The more indented line returns its value to the previous, less indented line.

The infix gives a value, so it needs the `.` as prefix to return the value.

8 Name logic with `define :`

```
define : same-height? tree-height-a tree-height-b
  = tree-height-a tree-height-b
same-height? 3 3
;; also works with infix
. {3 same-height? 3}
```

```
$1 = #t
$2 = #t
```

By convention, logic that returns true or false has the suffix `?`.

You can use your own named logic like all other logic.

> What this map of Scheme calls *named logic* is commonly called `function` or `procedure`. We'll stick with *logic* for the sake of a leaner conceptual mapping.

The indented lines with the logic named here are called the **body**. The body of named logic can have multiple lines. Only the value of the last is returned.

```
define : unused-comp value
  = 2 value ;; not returned
  = 3 value ;; returned
unused-comp 2
unused-comp 3
```

```
$1 = #f
$2 = #t
```

9 Name a name using `define` with .

```
define small-tree-height-meters 3
define height
  . small-tree-height-meters
. height
```

```
$1 = 3
```

. returns the value of its line.

10 Return the value of logic with .

```
define : larger-than-4? size
  . {size > 4}
. larger-than-4?
```

```
$1 = #<procedure larger-than-4? (size)>
```

The value of logic defined with `define :` is a `procedure`. You can see the arguments in the output: If you call it with too few or too many arguments, you get warnings.

There are other kinds of logic: syntax rules and reader-macros. We will cover syntax rules later. New reader macros are rarely needed; using `{...}` for infix math is a reader macro.

11 Name inside `define` : with `define`

```
define birch-h/m 3
define : birch-is-small
  define reference-h/m 4
  . { birch-h/m < reference-h/m }
birch-is-small
```

```
$1 = #t
```

Only the last part is returned.

Note the `.` in front of the `{ birch-h/m < reference-h/m }`: a calculation inside braces is executed in-place. It is its result, so its value needs to be returned.

Zen for Scheme

A Zen for Scheme part 1: Birds Eye

RR Remove limitations to Reduce the feature-count you need,
*but **OM**: Optimizability Matters.*

FI Freedom for Implementations and from Implementations,
*but **CM**: Community Matters: Join the one you choose.*

SL Mind the Small systems!
And the Large systems!

ES Errors should never pass silently,
unless speed is set higher than safety.

Thanks for the error-handling principle goes to John Cowan.

12 Name the result of logic in one line with : or ()

```
define birch-h/m 3
define chestnut-h/m 5

define same-height : = birch-h/m chestnut-h/m
. same-height
define same-height-again (= birch-h/m chestnut-h/m)
. same-height-again
```

```
$1 = #f
$2 = #f
```

This is consistent with infix-math and uniform with defining logic:

```
define birch-h/m 3
define chestnut-h/m 5

define same-height {birch-h/m = chestnut-h/m}
. same-height
;; define logic
define : same-height? tree-height-a tree-height-b
  = tree-height-a tree-height-b
;; using the defined logic looks like defining it
define same-height : same-height? birch-h/m chestnut-h/m
. same-height
```

```
$1 = #f
$2 = #f
```

13 Name text with "

```
define tree-description "large tree"
define footer "In Love

Arne"
define greeting
  . "Hello"
display footer
```

```
In Love

Arne
```

Like `{ }`, text (called `string` as in "string of characters") is its value.

Text can span multiple lines. Line breaks in text do not affect the meaning of code.

You can use `\n` to add a line break within text without having a visual line break. The backslash (\) is the escape character and `\n` represents a line break. To type a real \ within quotes (`"`), you must escape it as \\.

Text is stronger than comments:

```
define with-comment ;; belongs to coment
  ;; comment
  . "Hello ;; part of the text"
. with-comment
```

```
$1 = "Hello ;; part of the text"
```

Return the value with `.` to name text on its own line.

With `display` you can show text as it will look in an editor.

14 Take decisions with `cond`

```
define chestnut-h/m 5
define tree-description
  cond
    {chestnut-h/m > 4}
      . "large tree"
    : = 4 chestnut-h/m ;; check returned value
      . "four meter tree"
    else
      . "small tree"
. tree-description
```

```
$1 = "large tree"
```

`cond` checks its clauses one by one and uses the first with *value* `#true`. To `cond` every valid value is `#true` (`#t`) except for `#false` (`#f`).

```
cond
  5
    . #t
  else ;; else is #true in cond
    . #f
cond
  #f
    . #f
  else #t ;; can use the value directly
```

```
$1 = #t
$2 = #t
```

To use named logic, prefix it with `:` to check its *value*.

15 Use fine-grained numbers with number-literals

```
define more-precise-height 5.32517
define 100-meters 1e2
. more-precise-height
. 100-meters
```

```
$1 = 5.32517
$2 = 100.0
```

These are floating point numbers. They store approximate values in 64 bit binary, depending on the platform. Read all the details in the Guile Reference manual Real and Rational Numbers, the r5rs numbers, and IEEE 754.[1]

16 Use exact numbers with #e and quotients

```
define exactly-1/5 #e0.2
define exactly-1/5-too 1/5
. exactly-1/5
. exactly-1/5-too
```

```
$1 = 1/5
$2 = 1/5
```

Guile computations with exact numbers stay reasonably fast even for unreasonably large or small numbers.

[1]All links are listed on page 65.

17 See inexact value of exact number with `exact->inexact`

```
exact->inexact #e0.2
exact->inexact 1/5
exact->inexact 2e7
```

```
$1 = 0.2
$2 = 0.2
$3 = 2.0e7
```

The inverse is `inexact->exact`:

```
inexact->exact 0.5
```

```
$1 = 1/2
```

Note that a regular `0.2` need not be exactly `1/5`, because floating point numbers do not have an exact representation for that. You'll need `#e` to have precise `0.2`.

```
inexact->exact 0.2
. #e0.2
```

```
$1 = 3602879701896397/18014398509481984
$2 = 1/5
```

18 Use math with the usual operators as logic

```
define one-hundred
  * 10 10 ;; multiply with *
define half-hundred : / one-hundred 2 ;; divide with /
. half-hundred
```

```
$1 = 50
```

Remember that names cannot be valid numbers!

```
define 100 ;; error!
  * 10 10
```

```
While compiling expression:
Syntax error:
unknown location: source expression failed to match any
↪  pattern in form (define 100 (* 10 10))
```

Using infix via curly braces {} is useful for math:

```
define one-hundred {10 * 10}
define half-hundred {one-hundred / 2}
. half-hundred
```

```
$1 = 50
```

19 Return a list of values with `list`

```
list 3 5
define known-heights
  list 3 3.75 5 100
. known-heights
```

```
$1 = (3 5)
$2 = (3 3.75 5 100)
```

You can put values on their own lines by returning their value: `.` returns all the values in its line. Different from `define :`, list keeps all values, not just the last.

```
define known-heights-2
  list 3
      . 3.75 5
      . 100
define known-heights-3
  list
     . 3
     . 3.75
     . 5
     . 100
define : last-height
   . 3 3.75 5 100 ;; only the last (100) is returned
= 100 : last-height
```

```
$1 = #t
```

20 Compare structural values with equal?

```
= 3 3 3
;; reuse name definition snippets
{{{known-heights}}}
{{{known-heights2}}}
equal? known-heights known-heights-2 known-heights-3
```

```
$1 = #t
$2 = (3 5)
$3 = (3 3.75 5 100)
$4 = #t
$5 = #t
```

Like `=` and `+`, `equal?` can be used on arbitrary numbers of values.

Reusing the snippets here uses `noweb` syntax via Emacs Org Mode.

Zen for Scheme

A Zen for Scheme part 2: On the Ground

HA Hygiene reduces Anxiety,
except where it blocks your path.

PP Practicality beats Purity,
except where it leads into a dead end.

3P 3 Pillars of improvement:
Experimentation, Implementation, Standardization.

21 Apply logic to a list of values with `apply`

```
apply = : list 3 3
equal?
  = 3 3
  apply =
    list 3 3
```

```
$1 = #t
$2 = #t
```

Only the last argument of apply is treated as list, so you can give initial arguments:

```
define a 1
define b 1
apply = a b
  list 1 1
```

```
$1 = #t
```

Using `apply proc a (list b c)` has the same result as calling proc with the arguments `a b c`:

```
define : proc x y z
    < x y z
apply proc 1 : list 2 3
proc 1 2 3
```

```
$1 = #t
$2 = #t
```

22 Get the arguments of named logic as list with `. args`

```
define : same? heights
  apply = heights
same? : list 1 1 1 ;; needs a list to use apply
same?
  list 1 1 1
define : same2? . heights
  apply = heights
same2? 1 1 1 ;; takes values directly
same2?
  . 1 1 1
```

```
$1 = #t
$2 = #t
$3 = #t
$4 = #t
```

These are called `rest`. Getting them is not for efficiency: the list creation is implicit. You can mix regular arguments and `rest` arguments:

```
define : same? alice bob . rest
  display : list alice bob rest
  newline
  apply = alice bob rest
same? 1 1 1 1
```

```
(1 1 (1 1))
$1 = #t
```

Remember that apply uses only the last of its arguments as list, in symmetry with `. rest`. Beautiful symmetry.

23 Change the value or logic of a defined name with `set!`

```
define birch-h/m 3
set! birch-h/m 3.74
. birch-h/m
set! birch-h/m =
. birch-h/m
```

```
$1 = 3.74
$2 = #<procedure = (#:optional _ _ . _)>
```

It is common to suffix logic with `!` if it changes values of names.

Since logic can cause changes to names and not just return a result, it is not called `function`, but `procedure`; `proc` for brevity.

24 Apply logic to each value in lists with `for-each`

```
define birch-h/m 3
define includes-birch-height #f
define : set-true-if-birch-height! height/m
  cond
    {birch-h/m = height/m}
      set! includes-birch-height #t
define heights : list 3 3.75 5 100
for-each set-true-if-birch-height! heights
. includes-birch-height
```

```
$1 = #t
```

25 Get the result of applying logic to each value in lists with `map`

```
define birch-h/m 3
define : same-height-as-birch? height/m
  = birch-h/m height/m
define heights : list 3 3.75 5 100
. heights
map same-height-as-birch?
  . heights
map +
  list 1 2 3
  list 3 2 1
map list
  list 1 2 3
  list 3 2 1
```

```
$1 = (3 3.75 5 100)
$2 = (#t #f #f #f)
$3 = (4 4 4)
$4 = ((1 3) (2 2) (3 1))
```

When operating on multiple lists, `map` takes one argument from each list. All lists must be the same length. *To remember*: `apply` extracts the values from its *last argument*, `map` extracts one value from *each argument* after the first. `apply map list ...` flips colums and rows:

```
apply map list
  list : list 1 2 3
         list 3 2 1
```

```
$1 = ((1 3) (2 2) (3 1))
```

26 Create nameless logic with `lambda`

```
define : is-same-height? a b
  > a b ;; <- this is a mistake
. is-same-height?
is-same-height? 3 3
define : fixed a b
  = a b
set! is-same-height? fixed
. is-same-height? ;; but now called "fixed" in output!
is-same-height? 3 3
;; shorter and avoiding name pollution and confusion.
set! is-same-height?
  lambda : a b
    = a b ;; must be on a new line
          ;; to not be part of the arguments.
;; since lambda has no name, we see the original again
. is-same-height?
is-same-height? 3 3
```

```
$1 = #<procedure is-same-height? (a b)>
$2 = #f
$3 = #<procedure fixed (a b)>
$4 = #t
$5 = #<procedure is-same-height? (a b)>
$6 = #t
```

The return value of `lambda` is logic (a `procedure`).

If logic is defined via `define :`, it knows the name it has been defined as. With `lambda`, it does not know the name.

`lambda` is a special form. Think of it as `define : name arguments`, but without the name.

27 Reuse your logic with `let`-recursion

Remember the `for-each` example:

```
define includes-birch-height #f
define heights : list 3 3.75 5 100
define : set-true-if-birch-height! height/m
  define birch-h/m 3
  cond
    {birch-h/m = height/m}
      set! includes-birch-height #t
for-each set-true-if-birch-height! heights
. includes-birch-height
```

```
$1 = #t
```

Instead of `for-each`, we can build our own iteration:

```
define heights : list 3 3.75 5 100
define : includes-birch-height? heights
  define birch-h/m 3
  let loop : : heights heights
    cond
      (null? heights) #f ;; done: not found
      : = birch-h/m : car heights ;; car is first
        . #t ;; done: one found
      else
        loop : cdr heights ;; drop the first, try again
includes-birch-height? heights
```

```
$1 = #t
```

`null?` asks whether the list is empty. `car` gets the first element of a list, `cdr` gets the list without its first element.

Recursion is usually easier to debug (all variable elements are available at the top of the let recursion) and often creates cleaner APIs than iteration.

As rule of thumb: start with the recursion end condition (here: `(null? heights)`) and ensure that each branch of the `cond` either ends recursion or moves a step towards finishing (usually with `cdr`).

Another example why recursion wins:

```
define : fib n
   let rek : (i 0) (u 1) (v 1)
        if : >= i {n - 2}
           . v
           rek {i + 1} v {u + v}
```

Zen for Scheme

A Zen for Scheme part 3: Submerged in Code

WM Use the Weakest Method that gets the job done,
but know the stronger methods to employ them as needed.

RW Recursion Wins,
except where a loop-macro is better.

RM Readability matters,
and nesting works.

28 Import pre-defined named logic and values with `import`

```
import : ice-9 pretty-print
         srfi :1 lists ;; no space after the :

pretty-print ;; format a structure nicely
  list 12
    list 34
    . 5 6

first : list 1 2 3 ;; 1
second : list 1 2 3 ;; 2
third : list 1 2 3 ;; 3

member 2 : list 1 2 3 ;; includes 2 => 2 3 => #true
```

```
(12 (34) 5 6)
$1 = 1
$2 = 2
$3 = 3
$4 = (2 3)
```

Import uses modules which can have multiple components. In the first import, `ice-9` is one component and the second is `pretty-print`. In the second, `srfi` is the first component, `:1` is the second, and `lists` is the third.

ice-9 is the name for the core extensions of Guile. It's a play on ice-9, a fictional perfect seed crystal.

SRFI's are Scheme Requests For Implementation, portable libraries built in collaboration between different Scheme implementations. The ones available in Guile can be found in the Guile reference manual.

More can be found on srfi.schemers.org. They are imported by number (`:1`) and can have a third component with a name, but that's not required.

You can use `only` to import only specific names.

```
import : only (srfi :1) first second ;; no third
         only (srfi :1) iota

first : list 1 2 3 ;; 1
second : list 1 2 3 ;; 2
third : list 1 2 3 ;; error
iota 5 ;; list 0 1 2 3 4
```

```
$1 = 1
$2 = 2
ice-9/boot-9.scm:1683:22: In procedure raise-exception:
Unbound variable: third

Entering a new prompt.  Type `,bt' for a backtrace or `,q'
↪  to continue.
$3 = (0 1 2 3 4)
```

29 Extend a list with `cons`

The core of composing elementwise operations.

To build your own `map` function which returns a list of results, you need to add to a list. `cons` adds to the front:

```
cons 1 : list 2 3
;; => list 1 2 3
```

```
$1 = (1 2 3)
```

Used for a simplified `map` implementation that accepts only a single list:

```
import : only (srfi :1) first
define : single-map proc elements
  . "map procedure proc on each of the elements."
  let loop : (changed (list)) (elements elements)
    cond
      : null? elements
        reverse changed
      else
        loop
          ;; add processed first element to changed
          cons : proc : first elements
               . changed
          ;; drop first element from elements
          cdr elements
single-map even? : list 1 2 3
;; => #f #t #f
```

```
$1 = (#f #t #f)
```

30 Mutate partially shared state with `list-set!`

The elements in a list are linked from its start. Different lists can share the same tail when you cons onto the same partial list.

```
define tail ;; the shared tail
  list 3 2 1 ;; 3 2 1
define four ;; an intermediate list
  cons 4 tail ;; 4 3 2 1
define five ;; one more list
  cons 5 four ;; 5 4 3 2 1
define fourtytwo ;; branching off from tail
  cons 42 tail ;; 42 3 2 1
list-set! five 1 'four ;; change shared state
. five ;; changed directly: 5 four 3 2 1
. four ;; touched indirectly ;; four 3 2 1
. fourtytwo ;; not affected ;; 42 3 2 1
list-set! tail 1 'two ;; mutating the shared tail
. five ;; 5 four 3 two 1
. four ;; four 3 two 1
. fourtytwo ;; 42 3 two 1
. tail ;; 3 two 1
```

```
$1 = four
$2 = (5 four 3 2 1)
$3 = (four 3 2 1)
$4 = (42 3 2 1)
$5 = two
$6 = (5 four 3 two 1)
$7 = (four 3 two 1)
$8 = (42 3 two 1)
$9 = (3 two 1)
```

Mutating shared state often causes mistakes. Use it only when needed.

31 Apply partial procedures with `srfi :26 cut`

```
define : plus-3 number
  + 3 number
map plus-3
  list 1 2 3 ;; list 4 5 6

import : srfi :26 cut

define plus-3-cut : cut + 3 <>
;; the argument is used at <>
plus-3-cut 9 ;; => + 3 9 => 12
map plus-3-cut
  list 1 2 3 ;; list 4 5 6

;; defined directly
map : cut + 3 <>
  list 1 2 3 ;; list 4 5 6

map : cut - <> 1 ;; => <> - 1
  list 1 2 3 ;; list 0 1 2

map : cut - 1 <> ;; => 1 - <>
  list 1 2 3 ;; list 0 -1 -2
```

```
$1 = (4 5 6)
$2 = 12
$3 = (4 5 6)
$4 = (4 5 6)
$5 = (0 1 2)
$6 = (0 -1 -2)
```

This method is known in mathematics as “currying“.

32 Use r7rs datatypes, e.g. with vector-map

R7RS is the 7th Revised Report on Scheme. Guile provides a superset of the standard: its core can be imported as `scheme base`. A foundational datatype is Vector with `O(1)` random access guarantee.

```
import : scheme base
define vec : list->vector '(1 b "third")
vector-map : λ (element) : cons 'el element
           . vec
```

```
$1 = #((el . 1) (el . b) (el . "third"))
```

Vectors have the literal form `#(a b c)`. It is an error to mutate these.

```
import : scheme base
define mutable-vector : list->vector '(1 b "third")
define literal-vector #(1 b "third")
vector-set! mutable-vector 1 "bee" ;; allowed
. mutable-vector ;; 1 "bee" "third"
vector-set! literal-vector 1 "bee" ;; forbidden
. literal-vector ;; unchanged: 1 b "third"
```

```
$1 = #(1 "bee" "third")
ice-9/boot-9.scm:1683:22: In procedure raise-exception:
In procedure vector-set!: Wrong type argument in position
↪  1 (expecting mutable vector): #(1 b "third")

Entering a new prompt.  Type `,bt' for a backtrace or `,q'
↪  to continue.
$2 = #(1 b "third")
```

33 Name structured values with `define-record-type`

```
import : srfi :9 records

define-record-type <tree>
  make-tree kind height-m weight-kg carbon-kg
  . tree?
  kind tree-kind ;; the kind of tree, e.g. "birch"
  height-m tree-height
  weight-kg tree-weight
  carbon-kg tree-carbon

define birch-young
  make-tree "birch" 13 90 45 ;; 10 year, 10cm diameter,
define birch-old
  make-tree "birch" 30 5301 2650 ;; 50 year, 50cm
define birch-weights
  map tree-weight : list birch-young birch-old
. birch-young
. birch-old
. birch-weights ;; 90 5301
```

```
$1 = #<<tree> kind: "birch" height-m: 13 weight-kg: 90
↪   carbon-kg: 45>
$2 = #<<tree> kind: "birch" height-m: 30 weight-kg: 5301
↪   carbon-kg: 2650>
$3 = (90 5301)
```

Carbon content in birch trees is about 46% to 50.6% of the mass. See forestry commission technical paper 1993.

Height from Waldwissen, weight from BaumUndErde.

34 Make your names importable with `define-module`

To provide your own module, create a file named by the module name. For `import : example trees` the file must be `example/trees.w`. Use `define-module` and choose with `#:export` what gets imported:

```
define-module : example trees
              . #:export ;; the following is exported
              birch-young
                . make-tree tree? tree-carbon ;; continued
import : srfi :9 records ;; imports after module
define-record-type <tree> ;; minimal record  type
  make-tree carbon-kg
  . tree?
  carbon-kg tree-carbon
define birch-young
  make-tree 45 ;; about 10 years, 10cm diameter
```

To use that module, add your root folder to the search path. Then just import it. To ensure that the file is run correctly, use shell-indirection:

```
#!/usr/bin/env bash
exec -a "${0}" guile --language=wisp \
     -L "$(dirname "${0}")" -x .w $@
;; !# Wisp execution
import : example trees
. birch-young
```

```
$1 = #f
$2 = #<<tree> carbon-kg: 45>
```

Make executable with `chmod +x the-file.w`, run with `./the-file.w`

35 Get the result of logic inline with parentheses (), braces {}, or colon :

```
import : srfi :26 cut
list 1 2 (+ 1 2) 4
list 1 2 {1 + 2} 4
list 1 2 : + 1 2 ;; continue the arguments after :
   . 4
map (cut + 3 <>) : list 1 2 3
```

```
$1 = (1 2 3 4)
$2 = (1 2 3 4)
$3 = (1 2 3 4)
$4 = (4 5 6)
```

Line breaks and indentation are ignored inside parentheses, except for the value of `text` (`strings`).

The operators that need linebreaks are disabled inside parentheses: colon : and period . neither get the value nor return it, but the last value is returned implicitly. This is the default in regular Scheme.

: needs linebreaks, because it only goes to the end of the line.

. needs linebreaks, because it only applies at the beginning of the line (after indentation).

`cut` is logic that has logic as result.

36 Handle errors using `with-exception-handler`

```
;; unhandled exception stops execution
define : add-5 input
  + 5 input ;; illegal for text
map add-5 ' : "five" 6 "seven"
;; check inputs
define : add-5-if input
  if : number? input
     + 5 input
     . #f
map add-5-if ' : "five" 6 "seven"
;; handle exceptions
define : add-5-handler input
  with-exception-handler
    λ (e) : format #t "must be number, is ~S.\n" input
          . #f ;; result in case of error
    λ () : + 5 input
    . #:unwind? #t ;; #t: continue #f: stop
map add-5-handler ' : "five" 6 "seven"
```

```
$1 = #f
ice-9/boot-9.scm:1683:22: In procedure raise-exception:
In procedure +: Wrong type argument in position 1: "five"

Entering a new prompt.  Type `,bt' for a backtrace or `,q' to conti
$2 = (#f 11 #f)
must be number, is "five".
must be number, is "seven".
$3 = (#f 11 #f)
```

In Guile Wisp checking inputs is often cheaper than exception handling.

37 Test your code with `srfi 64`

Is your code correct?

```
import : srfi :64 testsuite

define : tree-carbon weight-kg
  * 0.5 weight-kg

define : run-tests
  test-begin "test-tree-carbon"
  test-equal 45.0
    tree-carbon 90
  test-approximate 45.0
    + 40 : random 10.0
    . 5 ;; expected error size
  test-assert : equal? 45.0 : tree-carbon 90 ;; #t
  test-error : throw 'wrong-value
  test-end "test-tree-carbon"

run-tests
```

```
*** Entering test group: test-tree-carbon ***
* PASS:
* PASS:
* PASS:
* PASS:
*** Leaving test group: test-tree-carbon ***
*** Test suite finished. ***
*** # of expected passes    : 4
$1 = #<<test-runner> result-alist: ((actual-error . #<&compound-exc
```

You can use this anywhere.

For details, see srfi 64.

38 Define derived logic structures with `define-syntax-rule`

In usual logic application of `procedures`, arguments are evaluated to their return value first: `procedures` evaluate from **inside to outside**:

```
import : ice-9 pretty-print
define : hello-printer . args
  pretty-print "Hello"
  for-each pretty-print args
hello-printer 1
  pretty-print "second" ;; "second" shown first
  . 3 4
```

```
"second"
"Hello"
1
#<unspecified>
3
4
```

The result of `pretty-print` is `#<unspecified>`

But for example `cond` only evaluates the required branches. It is not a `procedure`, but a `syntax-rule`. Syntax-rules evaluate from **outside to inside**:

```
import : ice-9 pretty-print
define-syntax-rule : early-printer args ...
  begin
    pretty-print "Hello"
    for-each pretty-print : list args ...
early-printer 1
  pretty-print "second" ;; "second" shown after "Hello"
  . 3 4
```

```
"Hello"
"second"
1
#<unspecified>
3
4
```

Arguments of `define-syntax-rule` are only evaluated when they are passed into a regular `procedure` or returned. By calling other `syntax-rules` in `syntax-rules`, evaluation can be delayed further.

`define-syntax-rule` can reorder arguments and pass them to other `syntax-rules` and to `procedures`. It cannot ask for argument values, because it does not evaluate names as values: it operates on names and structure.

Instead of `define : name . args`, it uses a pattern with `...`:

`define-syntax-rule : name args ...`

The ellipsis `...` marks `args` as standing for zero or more names. It must be used with the ellipsis as `args ...`.

The body of `define-syntax-rule` must only have one element. The logic `begin` wraps its own body to count as only one element. It returns the value of the last element in its body.

39 Get and resolve names used in code with `quote`, `eval`, and `module-ref`

```
list : quote alice
       quote bob
       quote carol
       quote dave
;; => (alice bob carol dave)

define alice "the first"

eval 'alice : current-module
;; => "the first"
module-ref (current-module) 'alice
;; => "the first"
;; module-ref is less powerful than eval. And safer.

define code
  quote
    list 1 2 3
. code
;; => (list 1 2 3)
;;    uses parentheses form
eval code : current-module
;; => (1 2 3)

' 1 2 3
;; (1 2 3)
list 1 2 3
;; (1 2 3)

equal? : ' 1 2 3
      list 1 2 3
```

```
$1 = (alice bob carol dave)
$2 = "the first"
$3 = "the first"
$4 = (list 1 2 3)
$5 = (1 2 3)
$6 = (1 2 3)
$7 = (1 2 3)
$8 = #t
```

The form `' 1 2 3` is a shorthand to create an **immutable** (literal) list that is `equal?` to `list 1 2 3`.

But some operations like `list-set! the-list index new-value` from `srfi :1` do not work on immutable lists.

```
define mutable-list : list 1 2 3
list-set! mutable-list 1 'a ;; zero-indexed: a replaces 2
. mutable-list
define immutable-list : ' 1 2 3
. immutable-list
list-set! immutable-list 1 'a ;; error!
```

```
$1 = a
$2 = (1 a 3)
$3 = (1 2 3)
ice-9/boot-9.scm:1683:22: In procedure raise-exception:
In procedure set-car!: Wrong type argument in position 1
↪  (expecting mutable pair): (2 3)

Entering a new prompt.  Type `,bt' for a backtrace or `,q'
↪  to continue.
```

40 Build value-lists with quasiquote and unquote

```
define : tree-manual type height weight carbon-content
  list : cons 'type type
         cons 'height height
         cons 'weight weight
         cons 'carbon-content carbon-content
tree-manual "birch" 13 90 45

define : tree-quasiquote type height weight carbon-content
  quasiquote
    :
      type . : unquote type
      height . : unquote height
      weight . : unquote weight
      carbon-content . : unquote carbon-content
tree-quasiquote "birch" 13 90 45

define : tree-shorthand type height weight carbon-content
  ` : type . ,type      ;; ` is short for quasiquoted list
      height . ,height ;; , is short for unquote
      weight . ,weight
      carbon-content . ,carbon-content
tree-shorthand "birch" 13 90 45
```

```
$1 = ((type . "birch") (height . 13) (weight . 90)
↪  (carbon-content . 45))
$2 = ((type . "birch") (height . 13) (weight . 90)
↪  (carbon-content . 45))
$3 = ((type . "birch") (height . 13) (weight . 90)
↪  (carbon-content . 45))
```

These three methods are almost equivalent, except that quasiquoting can create an immutable list, but this is not guaranteed.

```
define three 3
define mutable-list : list 1 2 3
list-set! mutable-list 1 'a ;; zero-indexed
. mutable-list
define immutable-list : ` 1 2 3
list-set! immutable-list 1 'a ;; error!
. immutable-list
define mutable-quasiquoted : ` 1 2 ,three
list-set! mutable-quasiquoted 1 'a ;; currently no error!
. mutable-quasiquoted
```

```
$1 = a
$2 = (1 a 3)
ice-9/boot-9.scm:1683:22: In procedure raise-exception:
In procedure set-car!: Wrong type argument in position 1
↪  (expecting mutable pair): (2 3)

Entering a new prompt.  Type `,bt' for a backtrace or `,q'
↪  to continue.
$3 = (1 2 3)
$4 = a
$5 = (1 a 3)
```

Mutating quasiquoted lists may throw an error in the future. From the standard:

> A quasiquote expression may return either newly allocated, mutable objects or literal structure for any structure that is constructed at run time …

41 Merge lists with `append` or `unquote-splicing`

```
define birch-carbon/kg '(5000 5301 5500)
define oak-carbon/kg '(7000 7700 8000)
;; append merges lists
append birch-carbon/kg
  . oak-carbon/kg
;; unquote-splicing splices a list into quasiquote (`)
` : unquote-splicing birch-carbon/kg
  unquote-splicing oak-carbon/kg
;; with shorthand ,@, note the leading period (.)
` ,@birch-carbon/kg
  . ,@oak-carbon/kg
```

```
$1 = (5000 5301 5500 7000 7700 8000)
$2 = (5000 5301 5500 7000 7700 8000)
$3 = (5000 5301 5500 7000 7700 8000)
```

Unquote splicing can also insert the result of logic:

```
` : ,@ map 1- '(1 2 3)
  ,@ map 1+ : reverse '(0 1 2)
  unquote-splicing : list 0
```

```
$1 = (0 1 2 3 2 1 0)
```

The shorthand `,@` can be used with parentheses, but the parentheses must come after it and all calls inside must use parentheses:

```
` ,@(map 1- '(1 2 3))
  . ,@(map 1+ (reverse '(0 1 2)))
  . (unquote-splicing (list 0))
```

42 Document procedures with docstrings

```
define : documented-proc arg
  . "Proc is documented"
  . #f ;; documentation must not be the last element
procedure-documentation documented-proc
;; variables have no docstrings but
;; properties can be set manually.
define variable #f
set-object-property! variable 'documentation
  . "Variable is documented" ;; returns the value
object-property variable 'documentation
```

```
$1 = "Proc is documented"
$2 = "Variable is documented"
$3 = "Variable is documented"
```

You can get the documentation with `help` or `,d` on the REPL:

```
,d documented-proc => Proc is documented
,d variable => Variable is documented
```

For generating documentation from comments, there's `guild doc-snarf`.

```
;; Proc docs can be snarfed
define : snarfed-proc arg
  . #f
;; Variable docs can be snarfed
define snarfed-variable #f
```

If this is saved as hello.w, get the docs via

```
wisp2lisp hello.w > hello.scm && \
    guild doc-snarf --texinfo hello.scm
```

43 Read the docs

Now you understand the heart of code. With this as the core there is one more step, the lifeblood of programming: learning more. Sources:

- the Guile Reference manual
- the Guile Library
- Scheme Requests for Implementation (SRFI): tagged libraries
- The Scheme standards (RnRS), specifically r7rs-small (pdf)
- a list of tools and libraries
- Rosetta Code with solutions to many algorithm problems

Info manuals can often be read online, but the `info` commandline application and `info` in Emacs (`C-h i`) are far more efficient and provide full-text search. You can use them to read the Guile reference manual and some libraries. Get one by installing texinfo or Emacs.

In **interactive** `wisp` (the REPL), you can check documentation:

```
help string-append .
```

```
`string-append' is a procedure in the (guile) module.

- Scheme Procedure: string-append .  args
     Return a newly allocated string whose characters form the
     concatenation of the given strings, ARGS.
```

```
,help
```

```
Help Commands [abbrev]:
...
```

Note: the full links are printed in the list of links on page 65.

44 Create a manual with `texinfo`

Create a `doc/` folder and add a `hello.texi` file.

An **example file** can look like the following:

```
@documentencoding UTF-8
@settitle Hello World
@c This is a comment; The Top node is the first page
@node Top

@c Show the title and clickable Chapter-names as menu
@top
@menu
* First Steps::
* API Reference::
@end menu

@contents
@node First Steps
@chapter First Steps
@itemize
@item
Download from ...
@item
Install: @code{make}.
@end itemize

Example:
@lisp
(+ 1 2)
@result{} 3
@end lisp

@node API Reference
```

```
@chapter API Reference
@section Procedures
@subsection hello
Print Hello
@example
hello
@end example
```

Add a `Makefile` in the doc/ folder:

```
all: hello.info hello.epub hello_html/index.html
hello.info: hello.texi
    makeinfo hello.texi
hello.epub: hello.texi
    makeinfo --epub hello.texi
hello_html/index.html: hello.texi
    makeinfo --html hello.texi
```

Run make:

```
make
```

Read the docs with `calibre` or the `browser` or plain `info`:

```
calibre hello.epub & \
firefox hello_html/index.html & \
info -f ./hello.info
```

The HTML output is plain. You can adapt it with CSS by adding `--css-include=FILENAME` or `--css-ref=URL` to `make info`.

Alternately you can write an Org Mode document and evaluate `(require 'ox-texinfo)` to activate exporting to texinfo.

45 Track changes with a version tracking system like `Mercurial` or `Git`

For convenience, first initialize a version tracking repository, for example Mercurial or Git.

```
# either Mercurial
hg init hello
# or Git
git init hello
# enter the repository folder
cd hello/
```

Now you can add new files with

```
# in Mercurial
hg add FILE
# in Git
git add FILE
```

And take a snapshot of changes with

```
# in Mercurial
hg commit -m "a change description"
# in Git
git commit -a -m "a change description"
```

It is good practice to always use a version tracking system.

For additional information and how to publish your code if you want to, see the Mercurial Guide or the Git Tutorial.

46 Package with autoconf and automake

Create a configure.ac file with name, contact info, and version.

```
# Name, Version, and contact information.
AC_INIT([hello], [0.0.1], [my-name@example.com])
# Find a supported Guile version and set it as @GUILE@
GUILE_PKG([3.0])
GUILE_PROGS
GUILE_SITE_DIR
AC_PREFIX_PROGRAM([guile])
AM_INIT_AUTOMAKE([gnu])
AC_CONFIG_FILES([Makefile])
AC_OUTPUT
```

Add a Makefile.am with build rules. Only the start needs to be edited:

```
bin_SCRIPTS = hello # program name
SUFFIXES = .w .scm .sh
WISP = hello.w # source files
hello: $(WISP)
	echo "#!/usr/bin/env bash" > "$@" && \
	echo 'exec -a "$$0" guile' \
	  '-L "$$(dirname "$$(realpath "$$0")")"' \
	  '-L "$$(dirname "$$(realpath
	  ↪  "$$0")")/../share/guile/site/3.0/"' \
	  '--language=wisp -x .w -s "$$0" "$$@"' \
	  >> "$@" && echo ";; exec done: !#" >> "$@" && \
	cat "$<" >> "$@" && chmod +x "$@"
TEXINFO_TEX = doc/hello.texi # else it needs texinfo.texi
info_TEXINFOS = doc/hello.texi
# add library files, prefix nobase_ preserves directories
nobase_site_DATA =
```

The rest of the Makefile.am can be copied verbatim:

```
## Makefile.am technical details

# where to install guile modules to import. See
# https://www.gnu.org/software/automake/manual/html_node/Alte⌋
↪  rnative.html
sitedir = $(datarootdir)/guile/site/$(GUILE_EFFECTIVE_VERSION)

GOBJECTS = $(nobase_site_DATA:%.w=%.go)
nobase_go_DATA = $(GOBJECTS)
godir=$(libdir)/guile/$(GUILE_EFFECTIVE_VERSION)/site-ccache

# Make sure that the mtime of installed compiled files
# is greater than that of installed source files.  See:
# http://lists.gnu.org/archive/html/guile-devel/2010-07/msg00⌋
↪  125.html
# The missing underscore before DATA is intentional.
guile_install_go_files = install-nobase_goDATA
$(guile_install_go_files): install-nobase_siteDATA

EXTRA_DIST = $(WISP) $(info_TEXINFOS) $(nobase_site_DATA)
CLEANFILES = $(GOBJECTS) $(wildcard *~)
DISTCLEANFILES = $(bin_SCRIPTS) $(nobase_site_DATA)

# precompile all source files
.w.go:
	$(GUILE_TOOLS) compile --from=wisp $(GUILE_WARNINGS) \
	   -o "$@" "$<"
```

```
## Makefile.am help

.PHONY: help
help: ## Show this help message.
	@echo 'Usage:'
	@echo ':make [target] ...' \
		| sed "s/\(target\)/\\x1b[36m\1\\x1b[m/" \
		| column -c2 -t -s :
	@echo
	@echo 'Custom targets:'
	@echo -e "$$(grep -hE '^\S+:.*##' $(MAKEFILE_LIST) \
		| sed -e \
		  's/:.*##\s*/:/' -e \
		  's/^\(.\+\):\(.*\)/:\\x1b[36m\1\\x1b[m:\2/' \
		| column -c2 -t -s :)"
	@echo
	@echo '(see ./configure --help for setup options)'

COPYING: ## create the license file
	curl -o "$@" https://www.gnu.org/licenses/gpl-3.0.txt
```

*This assumes that the folder **`hello`** uses a Version tracking system.*

```
## Makefile.am basic additional files
.SECONDARY: ChangeLog AUTHORS
ChangeLog: ## create the ChangeLog from the history
    echo "For user-visible changes, see the NEWS file" > "$@"
    echo >> "$@"
    if test -d ".git"; \
        then cd "$(dirname "$(realpath .git)")"  \
        && git log --date-order --date=short \
        | sed -e '/^commit.*$/d' \
        | awk '/^Author/ {sub(/\\$/,""); getline t; print $0
        ↪   t; next}; 1' \
        | sed -e 's/^Author: //g' \
        | sed -e \
          's/\(.*\)>Date:   \([0-9]*-[0-9]*-[0-9]*\)/\2
          ↪   \1>/g' \
        | sed -e 's/^\(.*\) \(\)\t\(.*\)/\3    \1    \2/g' \
           >> "$@"; cd -; fi
    if test -d ".hg"; \
        then hg -R "$(dirname "$(realpath .hg)")" \
           log --style changelog \
           >> "$@"; fi
AUTHORS: ## create the AUTHORS file from the history
    if test -d ".git"; \
        then cd "$(dirname "$(realpath .git)")"  \
          && git log --format='%aN' \
          | sort -u >> "$@"; cd -; fi
    if test -d ".hg"; \
        then hg -R "$(dirname "$(realpath .hg)")" \
            --config extensions.churn= \
            churn -t "{author}" >> "$@"; fi
```

Now create a `README` and a `NEWS` file:

```
#+title: Hello

A simple example project.

* Requirements

- Guile version 3.0.10 or later.

* Build the project

#+begin_src bash
,# Build the project
autoreconf -i && ./configure && make
,# Create a distribution tarball
autoreconf -i && ./configure && make dist
#+end_src

* License

GPLv3 or later.
```

```
hello 0.0.1

- initialized the project
```

And for the sake of this example a simple `hello.w` file:

```
display "Hello World!\n"
```

47 Deploy a project to users

Enable people to access your project as a webserver behind nginx, as clientside browser-app, or as Linux package (Guix tarball).

Browser: as webserver. *On the web no one knows you're a Scheme.*

Guile provides a webserver module. A minimal webserver:

```
import : web server
         web request
         web response
         web uri
define : handler request body
  define path : uri-path : request-uri request
  values
      build-response
        . #:headers `((content-type . (text/plain)))
        . #:code 404
      string-append "404 not found: " path ;; content
define v4 #t
;; choose either IPv4 or IPv6; to suport both, run twice.
;; run-server handler 'http
;;    if v4 '(#:port 8081) '(#:family AF_INET6 #:port 8081)
```

An nginx SSL Terminator (`/etc/nginx/sites-enabled/default`):

```
server {
  server_name domain.example.com;
  location / {
    proxy_pass http://localhost:8081;
  }
}
```

Set up SSL support with certbot (this edits the config file).

Browser again: clientside wasm. To run clientside, you can package your project with Hoot: build an interface, add your code, and compile to wasm:

```
;; save this file as hoot.w
use-modules : hoot ffi ;; guile-specific import
;; the interface
define-foreign document-body "document" "body"
  . -> (ref null extern)
define-foreign make-text-node "document" "createTextNode"
  . (ref string) -> (ref null extern)
define-foreign append-child! "element" "appendChild"
  . (ref null extern) (ref null extern)
  . -> (ref null extern)

;; your code
append-child! : document-body
  make-text-node "Hello, world!"
```

Transpile with `wisp2lisp` and `guild compile-wasm`. If you run Guix:

```
wisp2lisp hoot.w > hoot.scm && \
  guix shell guile-hoot guile-next -- \
    guild compile-wasm -o hoot.wasm hoot.scm
```

Get reflection tools from Guile Hoot (licensed Apache 2.0) with Guix:

```
guix shell guile-hoot guile-next --  bash -c \
 'cp $GUIX_ENVIRONMENT/share/guile-hoot/*/reflect*/{*.js,␣
 ↪  *.wasm}
 ↪  ./'
```

Load your interface:

```
// save this file as hoot.js
window.addEventListener("load", () =>
  Scheme.load_main("./hoot.wasm", {
    user_imports: {
      document: {
        body() { return document.body; }, // getter for
        ↪  body
        createTextNode: Document.prototype // bound logic
          .createTextNode.bind(document)
      },
      element: {
        appendChild(parent, child) { // explicit logic
          return parent.appendChild(child);
        }}}}));
```

Include `reflect.js` and `hoot.js` from a HTML page:

```
<html><head><title>Hello Hoot</title>
<script type="text/javascript" src="reflect.js"></script>
<script type="text/javascript" src="hoot.js"></script>
</head><body><h1>Hoot Test</h1></body></html>
```

For local testing, hoot provides a minimal webserver:

```
guix shell guile-hoot guile-next -- \
  guile -c '((@ (hoot web-server) serve))'
```

Linux: Guix tarball. *The package is the tarball. — Ludovic*

Guix can assemble a tarball of all dependencies. If you already have an autoconf project, this just requires a `guix.scm` file:

```
(import (gnu packages web)
    (gnu packages bash)
    (gnu packages guile)
    (gnu packages guile-xyz)
    (gnu packages pkg-config)
    (guix packages)
    (guix gexp)
    (guix build-system gnu)
    (prefix (guix licenses) license:))

(define-public guile-doctests
  (package
   (name "guile-doctests")
   (version "0.0.1")
   (source (local-file "." "" #:recursive? #t))
   (build-system gnu-build-system)
   (propagated-inputs `(("guile" ,guile-3.0)
                        ("pkg-config" ,pkg-config)
                        ("bash" ,bash)
                        ("guile-wisp" ,guile-wisp)))
   (home-page "https://hg.sr.ht/~arnebab/guile-doctests")
   (synopsis "Tests in procedure definitions")
   (description "Guile module to keep tests directly in
 ↪  your procedure definition.")
   (license license:lgpl3+)))

guile-doctests
```

First test building `guix build -f guix.scm`, then test running with `guix shell -f guix.scm`. Once both work, create your package with:

```
guix pack -e '(load "guix.scm")' \
     -RR -S /bin=bin -S /share=share
```

Copy the generated tarball. In can be executed with:

```
mkdir hello && cd hello && tar xf TARBALL_FILE && \
  bin/doctest
```

Since this tarball generation is a bit finicky, there is a guile-doctests package with a working example setup. Note the `wisp2lisp` call in the `Makefile.am` to prepare the `guix.scm` file.

Once you have `guix pack` working, you can also create `dockerfiles` and other packages to deploy into different publishing infrastructure.

To be continued: Scheme is in constant development and deploying Guile programs is getting easier. Lilypond solved Windows.

Also see the Map of R^7RS and the Scheme primer to keep learning.

You are ready.

Go and build a project you care about.

List of Links

»*I tend to use [Wisp] as a* ***Scheme primer*** *for colleagues used to Python who want to explore the realms of functional programming. It makes Scheme way more "approachable"*«
— Wilko

Get the gist of Lisp in practical steps.

»*The more time passes, the more I admire Wisp!*«
— Christine Lemmer-Webber from Spritely Institute.

This book guides you into **the heart of programming** with Scheme, using the approachable equivalent syntax of *Wisp* to smooth the start of your journey into one of the oldest standardized and thriving languages.

»*Wisp allows people to see code how Lispers perceive it. Its structure becomes apparent.*«
— Ricardo Wurmus about reproducible science with GWL.

We are the namegivers,
the dreamers who build tools of sand and logic
to **surpass the limits of our minds**.

»*I expected Wisp to be more of a fun toy to play around with and kind of just discard, but I have actually found it insanely useful to getting stuff done.*«
— kb

Choose your path
through **a map of building blocks**
to take on challenges by code.

»*I love the syntax of Python, but crave the simplicity and power of Lisp.*«
— Arne Babenhauserheide