

## Representing Lists

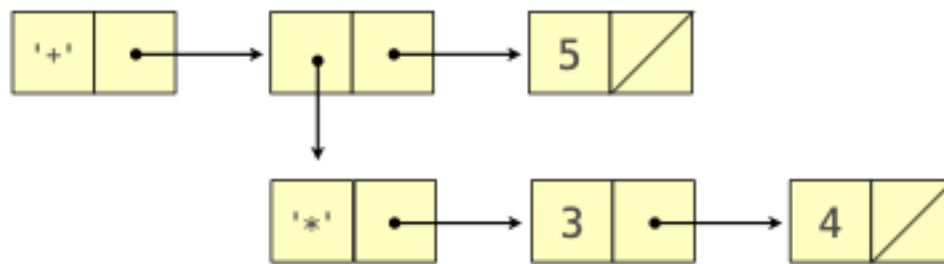
A Scheme call expression is a Scheme list that is represented using a `Link` instance in Python.

For example, the call expression `(+ (* 3 4) 5)` is represented as:

```
Link('+', Link(Link('*', Link(3, Link(4, nil))), Link(5, nil)))
```

Those `nil`'s are optional because `nil` is `Link.empty`, which is the default second argument to the `__init__` method of the `Link` class.

```
Link('+', Link(Link('*', Link(3, Link(4))), Link(5)))
```



`(+ (* 3 4) 5)`

The `Link` class and `nil` object are defined in `link.py` of the [Scheme project](#).

```
class Link:
    "A Scheme list is a Link in which rest is a Link or nil."
    empty = ()
    def __init__(self, first, rest=empty):
        self.first = first
        self.rest = rest

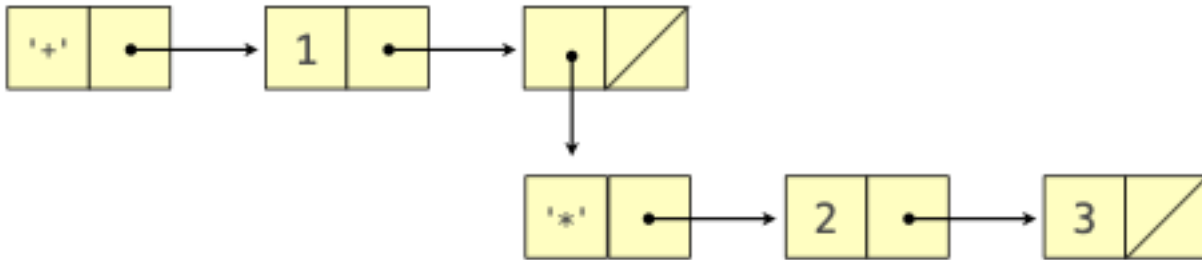
    ... # There are also __str__, __repr__, and map methods, omitted here.

nil = Link.empty
```

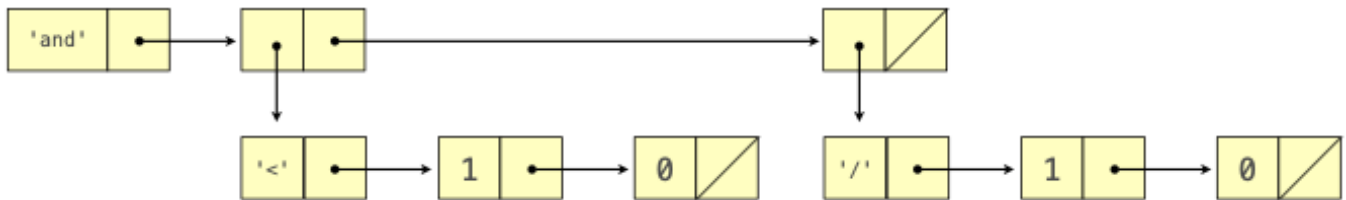
**Q1: Representing Expressions**

Write the Scheme expression in Scheme syntax represented by each Link below.

```
>>> Link('+', Link(1, Link(Link('*', Link(2, Link(3, nil))), nil)))
```



```
>>> Link('and', Link(Link('<', Link(1, Link(0, nil))), Link(Link('/', Link(1, Link(0, nil))), nil)))
```



Answer 1: `(+ 1 (* 2 3))`

Answer 2: `(and (< 1 0) (/ 1 0))`

# Evaluation

**Q2: Evaluation**

(Note: Some past exams have had a question in exactly this format.) Which of the following are evaluated when `scheme_eval` is called on `(if (< x 0) (- x) (if (= x -2) 100 y))` in an environment in which `x` is bound to `-2`? (Assume `<`, `-`, and `=` have their default values.)

- `if`
- `<`
- `=`
- `x`
- `y`
- `0`
- `-2`
- `100`
- `-`
- `(`
- `)`

To evaluate the expression `(+ (* 3 4) 5)` using the Project 4 interpreter, `scheme_eval` is called on the following expressions (in this order):

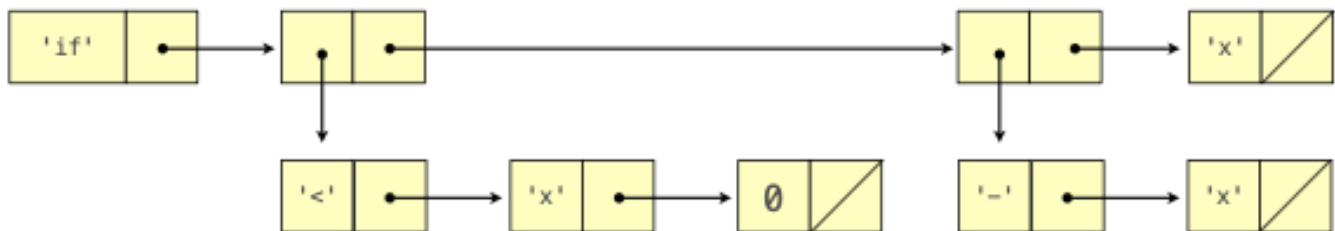
1. `(+ (* 3 4) 5)`
2. `+`
3. `(* 3 4)`
4. `*`
5. `3`
6. `4`
7. `5`

The `*` is evaluated because it is the operator sub-expression of `(* 3 4)`, which is an operand sub-expression of `(+ (* 3 4) 5)`.

An `if` expression is also a Scheme list represented using a `Link` instance.

For example, `(if (< x 0) (- x) x)` is represented as:

```
Link('if', Link(Link('<', Link('x', Link(0, nil))), Link(Link('-', Link('x', nil)), Link('x', nil))))
```



To evaluate this expression in an environment in which `x` is bound to 2 (and `<` and `-` have their default values), `scheme_eval` is called on the following expressions (in this order):

1. `(if (< x 0) (- x) x)`
2. `(< x 0)`
3. `<`
4. `x`
5. `0`
6. `x`

The symbol `if` is not evaluated because it is the start of a special form, not part of a call expression. The symbols that introduce special forms (`and`, `if`, `lambda`, etc.) are never evaluated.

The symbol `-` is not evaluated, nor is the whole sub-expression `(- x)` that it appears in, because `(< x 0)` evaluates to `#f`. **If you're still not certain why some parts are evaluated and some aren't, ask the course staff.**

### Q3: Print Evaluated Expressions

Define `print_evals`, which takes a Scheme expression `expr` that contains only numbers, `+`, `*`, and parentheses. It prints all of the expressions that are evaluated during the evaluation of `expr`. They are printed in the order that they are passed to `scheme_eval`.

**Note:** Calling `print` on a `Link` instance will print the Scheme expression it represents.

```
>>> print(Link('+', Link(Link('*', Link(3, Link(4, nil))), Link(5, nil))))
(+ (* 3 4) 5)
```

```

def print_evals(expr):
    """Print the expressions that are evaluated while evaluating expr.

    expr: a Scheme expression containing only (, ), +, *, and numbers.

    >>> nested_expr = Link('+', Link(Link('*', Link(3, Link(4, nil))), Link(5, nil)))
    >>> print_evals(nested_expr)
    (+ (* 3 4) 5)
    +
    (* 3 4)
    *
    3
    4
    5
    >>> print_evals(Link('*', Link(6, Link(7, Link(nested_expr, Link(8, nil)))))
    (* 6 7 (+ (* 3 4) 5) 8)
    *
    6
    7
    (+ (* 3 4) 5)
    +
    (* 3 4)
    *
    3
    4
    5
    8
    """
    if not isinstance(expr, Link):
        print(expr)
    else:
        print(expr)
        while expr is not nil:
            print_evals(expr.first)
            expr = expr.rest

```

# More Scheme!

## Q4: Slice It!

Implement the `get-slicer` procedure, which takes integers `a` and `b` and returns an *a-b slicing function*. An *a-b* slicing function takes in a list as input and outputs a new list with the values of the original list from index `a` (inclusive) to index `b` (exclusive).

Your implementation should behave like Python slicing, but should assume a step size of one with no negative slicing indices. Indices start at zero.

**Note:** the skeleton code is just a suggestion. Feel free to use your own structure if you prefer.

```
(define (get-slicer a b)
  (define (slicer lst)
    (define (slicer-helper c i j)
      (cond
        ((or (null? c) (<= j i)) nil)
        ((= i 0) (cons (car c) (slicer-helper (cdr c) i (- j 1))))
        (else (slicer-helper (cdr c) (- i 1) (- j 1))))
      (slicer-helper lst a b))
    slicer)

; DOCTESTS (No need to modify)
(define a '(0 1 2 3 4 5 6))
(define one-two-three (get-slicer 1 4))
(define one-end (get-slicer 1 10))
(define zero (get-slicer 0 1))
(define empty (get-slicer 4 4))

(expect (one-two-three a) (1 2 3))
(expect (one-end a) (1 2 3 4 5 6))
(expect (zero a) (0))
(expect (empty a) ())
```

## Q5: Reverse

Write the procedure `reverse`, which takes in a list `lst` and outputs a reversed list.

*Hint:* you may find the built-in `append` procedure useful.

```
(define (reverse lst)
  (if (null? lst)
      nil
      (append
        (reverse (cdr lst))
        (list (car lst)))))
)
```

6 *Interpreters*

