EXAM PREPARATION SECTION 9

MORE SCHEME, INTERPRETERS, STREAMS AND MACROS

April 18 to April 19, 2018

1 Scheme

1. Implement `non-contiguous`, which takes in two lists, `subseq` and `lst`, and returns whether `subseq` is a non-contiguous subsequence of `lst`. A sequence is a non-contiguous subsequence if its elements appear in the list in order but not necessarily immediately next to each other.

```
scm> (non-contiguous '() lst)
True
scm> (non-contiguous '(1 3 6) '(1 2 3 4 5 6))
True
scm> (non-contiguous '(1 5 2) '(1 2 3 4 5 6))
False
```

```
(define (non-contiguous subseq lst)
    (cond _____)
          _____
          _____)
          (else _____)))
```

Is this procedure properly tail recursive? _____

Implement `assert-equals` that takes in an expected value, `expected`, and an expression, `expression`, and returns whether the `expression` evaluates to the `expected value` to check whether your implementation works!

```
scm> (assert-equals #t '(non-contiguous '(1 3 6) '(1 2 3 4 5 6)))
ok
scm> (assert-equals #f '(non-contiguous '(1 5 2) '(1 2 3 4 5 6))
ok
scm> (assert-equals #t '(non-contiguous '(1 5 2) '(1 2 3 4 5 6))
(expected #t but got #f)
```

```
(define (assert-equals expected expression)
    (if _____)
        'OK
        _____))
```

2. **Lazy Sunday (Fa14 Final Q4c)** Implement the Scheme procedure `directions`, which takes a number `n` and a symbol `sym` that is bound to a nested list of numbers. It returns a Scheme expression that evaluates to `n` by repeatedly applying `car` and `cdr` to the nested list. Assume that `n` appears exactly once in the nested list bound to `sym`.

   Hint: The implementation searches for the number `n` in the nested list `s` that is bound to `sym`. The returned expression is built during the search. See the tests at the bottom of the page for usage examples.

```
(define (directions n sym)
    (define (search s exp)
        ; Search an expression s for n and return an
          expression based on exp.

        (cond ((number? s) _____)
              ((null? s) nil)
              (else (search-list s exp))))

    (define (search-list s exp)

        ; Search a nested list s for n and return an
          expression based on exp.

        (let ((first _____)

              (rest  _____))
                  (if (null? first) rest first)))
    (search (eval sym) sym))

(define a '(1 (2 3) ((4))))
(define b '((3 4) 5))

(directions 1 'a)
; expect (car a)
(directions 2 'a)
; expect (car (car (cdr a)))
(directions 4 'b)
; expect (car (cdr (car b)))
(directions 4 'a)
; expect (car (car (car (cdr (cdr a)))))
```

   What expression will `(directions 4 'a)` evaluate to? _____

3. Interpreters: Implementing Special Forms (Su14 Final Q3)

In the Scheme project, you implemented several *special forms*, such as `if`, `and`, `begin`, and `or`. Now we're going to look at a new special form: `when`. A `when` expression takes in a `condition` and any number of other subexpressions, like this:

```
(when <condition>
      <exp>
      <exp>
      ...
      <exp>)
```

If `condition` is true, **all** of the following subexpressions are evaluated **in order** and the value of the `when` is the value of the last subexpression. If it is false, **none** of them are evaluated and the value of the `when` is `okay`. For example, `(when (= 1 1) (+ 2 3) (* 1 2))` would first evaluate `(+ 2 3)` and then `(* 1 2)`.

(a) (2 pt) Equivalent Scheme Expression Rewrite the `when` expression below into **another Scheme expression** which uses **only** the special forms you **already** implemented in your project. That is, create a Scheme expression which does the same thing as this `when` expression **without** using `when`. You should use `if` in your answer.

```
(when (= days-left 0)
      (print 'im-free)
      'jk-final)
```

You may or may not need to use all of the lines provided.

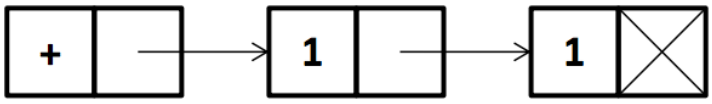
```
(-------------------------------------------------------------------------

    -------------------------------------------------------------------

    -------------------------------------------------------------------

    -------------------------------------------------------------------)
```

(b) (2 pt) Box and Pointer Remember that `do_when_form`, like the other do_something_form functions in the Scheme project, takes in `vals` and the `env` to evaluate in. We will be drawing the box-and-pointer diagram for `vals` above. As an example, the box-and-pointer diagram for `'(+ 1 1)` would be



In the example from the description, `vals` would be `'((= 1 1) (+ 2 3) (* 1 2))`. Draw the box-and-pointer diagram for this list in the space provided below.

(c) (3 pt) Implementing When Now implement `do_when_form`. Assume that the other parts of `scheme.py` have already been modified to accommodate this new special form. You may not need to use all of the lines provided. You do not need to worry about tail recursion. Remember that `do_when_form` must return *two* things - a Scheme expression or value and an environment or `None`.

```
def do_when_form(vals, env):

    ------------------------------------------------------

    ------------------------------------------------------
```

(d) (2 pt) Implementing Another Special Form Now let's implement another special form `until`, which takes in a `condition` and a series of expressions, and evaluates the expressions in order only if the `condition` is **NOT** true. Implement `do_until_form` using `do_when_form`. (Remember that Scheme has a built-in `not` function which your interpreter can evaluate!)

```
def do_until_form(vals, env):

    new_expr = ------------------------------------------------------
    return do_when_form(new_expr, env)
```

2 Streams

Repeat n Cycle Implement the Scheme procedure `cycle`, which takes in a list `lst` and a positive integer `n` and returns a Stream containing all the elements in `lst` repeated `n` times, with the feature of that the end of the stream points back to the beginning (therefore creating a cycle).

```
scm> (define a (cycle '(1 2 3) 3))
a
scm> (stream-to-list a 20)
(1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2)

(define (cycle lst n)
    ____________________________________________________________________

    ____________________________________________________________________

        (cond ____________________________________________________________

        ____________________________________________________________________

        ____________________________________________________________________
    s
)
```

Stream first n Implement the Scheme procedure `stream-first-n`, which takes in a positive integer `n` and a list `lst` and returns a Stream containing all the first `n` elements of `lst`, with the feature of that the end of the stream points back to the beginning.

```
scm> (stream-to-list (stream-first-n 3 '(1 2 3 4)) 10)
(1 2 3 1 2 3 1 2 3 1)
scm> (stream-to-list (stream-first-n 7 '(1 2 3 4)) 10)
(1 2 3 4 1 2 3 4 1 2)

(define (stream-first-n n lst)
    (define (stream-helper i curr-lst)

    _____________________________________________________________

        _____________________________________________________________

        _____________________________________________________________
    ))
(stream-helper n lst))
```

3 Macros

Suppose we wish to implement an OOP system in Scheme using macros. We will observe the following restriction: There are only **`class`**, attributes– no `instance` attributes. Implement `define-`**`class`**, `construct`, `define-method`, `call-method`, and `get-attr` macros below so that the Scheme OOP code has the same effect as the Python OOP code.

```
===== PYTHON OOP CODE =====
class Dog:
    def age_type():
        if Dog.a < 7:
            return "young"
        elif Dog.a > 7:
            return "old"
        else:
            return "middle aged"
Dog.n = "Fido"
Dog.a = 9
d = Dog()
print(d.age_type())
```

```
===== SCHEME OOP CODE =====
(define-class Dog)
(define-attr Dog n 'Fido)
(define-attr Dog a 9)
(define-method Dog (age-type)
    (cond
        ((< (get-attr Dog a) 7) 'young)
        ((> (get-attr Dog a) 7) 'old)
        (else 'middle-aged)
    )
)
(define d (construct Dog))
(print (call-method d (age-type)))

===== IMPLEMENTATION =====
(define-macro (define-class class-name)

    `(define ,class-name ____________________________________________________))

(define-macro (construct class-name)

    ____________________________________________________________________________)

(define-macro (define-attr class-name attr-name value)
    `(define
        ,class-name
        (cons

            '(_________________________________, _________________________________)
            ,class-name )))

(define-macro (get-attr class-name attr-name)
    `(begin
        (define (helper class)
            (if (eq? (quote ,attr-name) (car (car class)))
                (car (cdr (car class)))
                (helper (cdr class))))

        (helper ____________________________________________________________)))
(define-macro (define-method class-name signature body)

    `(define-attr ____________________________________________________________))

(define-macro (call-method instance call)

    (cons `(get-attr ,(eval instance) _________________) _____________________))
```