CSCI 301, Fall 2020
Lab 1 (Racket Introductory Lab)
DUE: 11:59pm Wednesday, 9/30, Online submission
25 Points Total

- This is an individual assignment. Work through the following lab.
- In this lab assignment, you will work experimentally with the DrRacket programming environment and the DrRacket language.
- Keep in mind that in addition to this lab, there are Racket and Scheme resources linked in the syllabus if you need help.
- Read the descriptions carefully and turn in the complete answers!
- When you are finished submit a copy of the document with your answers on Canvas.

Part 1: Getting started in DrRacket

1. Download and install DrRacket on your machine - https://download.racket-lang.org

   Select “Regular” variant.

2. Start up DrRacket, which is the programming environment that we’ll be using. If this is the first time you're starting up DrRacket, you'll see a warning about no language being specified. You can ignore it, and all will work; alternatively, you can go to the Languages menu for DrRacket, select "Choose Language," and make sure the first option is selected, which says "`Start your program with #lang...`"

3. You will see a pair of windows. The bottom window says "Welcome to DrRacket." That is the **interactions/execution** window. This is where you can test statements to see what they will do. Try it out - in the interactions window, type

   ```
   (+ 3 5)
   ```

   This should add 3 to 5. In Racket, + is a function. To call a function in Racket, you place the name of the function first and then its arguments, separated by spaces, inside parentheses. This takes a little getting used to! In most programming languages, function calls look something like this:

   ```
   function_name(arg1, arg2, arg3)
   ```

   In Racket, function calls look like this:

   ```
   (function_name arg1 arg2 arg3)
   ```

   Change your program in some way. For example, re-type it as

   ```
   (- -3 7)
   ```

   Experiment with hitting the `Esc` key followed by either the `p` or the `n` keys, which allow you to move backwards and forwards through your command history.

4. To run a program in DrRacket, either (1) type it into the edit (upper) window and then press Run (upper right), or type it into the interactions window and follow it with a new line (enter).

Part 2: Basic Racket Primitives

1. In the interactions window, enter the following

```
(car '(11 12 13 14))
(car '(a b c d))
(cdr '(11 12 13 14))
(cdr '(a b c d))
(car (11 12 13 14))
(cdr (a b c d))
```

What do `car` and `cdr` do? That last couple of lines of the above should cause an error. Explain why the single quote necessary and what it does.

Answer:

'car' will return the first element of a specific list

'cdr' will return the rest of the specified list

Single quote as the quote form produces a constant (quote datum)

2. Write sequences of `car`s and `cdr`s that will pick the symbol `'x` out of the following expressions:

```
(x y z m)
(y x z m)
(y z m x)
((y)(x)(z)(m))
((y z) (m x))
```

Answer:

1. (car '(x y z m))

2. (cdr '(y x z m))

(car '(x z m))

3. (cdr '(y z m x))

(cdr '(z m x))

(cdr '(m x))

(car '(x))

4. (cdr '((y)(x)(z)(m)))

(car '((x) (z) (m)))

(car '(x))

5. (cdr '((y z) (m x)))

(car '((m x)))

(cdr '(m x))

(car '(x))

3. Execute the following statements. Write down the return value for each statement and explain what each of the functions `cons`, `append`, and `list` does.

```
 ;; This is a comment, by the way!
(cons 3 '(1 2))
(cons '(1 5) '(2 3))
(list 3 '(1 2))
(list '(1 5) '(2 3))
(append '(1) '(2 3))
(append '(1 5) '(2 3))

(cons 'x '(1 2))
(list 1 2 3 '(4 5))
(cons '1 '2 '3 '(4 5))
```

Answer:

(cons 3 '(1 2))

'(3 1 2)

(cons '(1 5) '(2 3))

'((1 5) 2 3)

-> cons creates a new list cell (a.k.a. cons cell)

(list 3 '(1 2))

'(3 (1 2))

(list '(1 5) '(2 3))

'((1 5) (2 3))

-> list creates a new list, as cons creates a 'pair'

(append '(1) '(2 3))

'(1 2 3)

(append '(1 5) '(2 3))

'(1 5 2 3)

-> appends values of a list, as seen by the return statements

(cons 'x '(1 2))

'(x 1 2)

(list 1 2 3 '(4 5))

'(1 2 3 (4 5))

(cons '1 '2 '3 '(4 5))

-> arity mismatch, expected two arguments but given four

4. Execute the following code. Write down the return value for each statement and explain what each of the functions `length`, `reverse` and `member` does.

```
(length '(a b c))
(reverse '(a b c))
(member 'a '(a b c))
(member 'b '(a b c))
(member 'c '(a b c))
(member 'd '(a b c))
```

Answer:

(length '(a b c))

3

-> length returns the length of the specified list

(reverse '(a b c))

'(c b a)

-> reverse the specified list

(member 'a '(a b c))

'(a b c)

(member 'b '(a b c))

'(b c)

(member 'c '(a b c))

'(c)

(member 'd '(a b c))

#f

-> #f is false in racket

-> member locates the element in question, the tail of the list is returned with that value at the start.

Part 3: Saving your code

Entering your code interactively is fun, but not a good idea for creating large programs. A better way to go is to write your code, save it, then run it. Here's how to do it.

1. Start typing in some Racket code in the **definitions** window at the top of the screen. Make sure that the first line says:

   ```
   #lang racket
   ```

   Use any of the above examples that you wish. When finished, save your program by going to the File menu, and choosing Save Definitions.

2. Run your program by clicking on the clicking on the `Run` button, or by using the combination Ctrl-T.

   You should generally use this approach for entering and running Racket code, but entering code directly into the interactions window is good for testing out quick ideas.

Part 4: Conditionals

Racket has a number of different predicates for testing equality.

1. Try this code:

```
(equal? '(hi there) '(hi there))
(eqv? '(hi there) '(hi there))
(= '(hi there) '(hi there))  ;; yes, this will give an error
(equal? '(hi there) '(bye now))
(eqv? '(hi there) '(bye now))
(equal? 3 3)
(eqv? 3 3)
(= 3 3)
(equal? 3 (+ 2 1))
(eqv? 3 (+ 2 1))
(= 3 (+ 2 1))
(equal? 3 3.0)
(eqv? 3 3.0)
(= 3 3.0)
(equal? 3 (/ 6 2))
(eqv? 3 (/ 6 2))
(= 3 (/ 6 2))
(equal? -1/2 -0.5)
(eqv? -1/2 -0.5)
(= -1/2 -0.5)
```

Write down the return value for each of the statement and explain the difference among `equal?`, `eqv?`, and =.

```
(equal? '(hi there) '(hi there))
#t
(eqv? '(hi there) '(hi there))
#f
(= '(hi there) '(hi there))
-> contract violation
(equal? '(hi there) '(bye now))
#f
(eqv? '(hi there) '(bye now))
#f
(equal? 3 3)
#t
(eqv? 3 3)
#t
(= 3 3)
#t
(equal? 3 (+ 2 1))
#t
(eqv? 3 (+ 2 1))
#t
(= 3 (+ 2 1))
#t
(equal? 3 3.0)
#f
(eqv? 3 3.0)
#f
(= 3 3.0)
#t
(equal? 3 (/ 6 2))
#t
(eqv? 3 (/ 6 2))
#t
```

(= 3 (/ 6 2))

#t

(equal? -1/2 -0.5)

#f

(eqv? -1/2 -0.5)

#f

(= -1/2 -0.5)

#t

-> The 'equal?' predicate follows racket semantics, extended to work with symbolic values. The eq? predicate follows the Racket semantics for opaque or mutable datatypes, such as procedures or vectors, but not for immutable datatypes, such as lists, or transparent solvable types, such as reals. The '=' follows conventional racket semantics as well, working distinctly with numerical values- as seen in the return statements. We must be careful when using each type, as there are certain caveats which may return an unintended response.

2. Enter the following code:

```
(if (equal? 8 3)
    9
    10)
```

Modify the condition following `if` to get a different value to return.

Answer:

(if (equal? 8 8)

9

10)

9

[Note that Racket pays no attention whatsoever to how you indent your code. The above indenting is stylistically useful to see what the "`if`" function is doing.] For textual conventions in Racket programming, refer to https://docs.racket-lang.org/style/Textual_Matters.html

3. Enter the following code:

```
(cond ((equal? 16 3) (+ 3 8))
      ((equal? 16 8) 12)
      (else (* 6 3)))
```

Write the return value for the above code. If replace all of the 16's in the above code with 8, what is the return value? What about replace the 16's with 3? What does the `cond` function do?

Answer:

(cond ((equal? 16 3) (+ 3 8))

((equal? 16 8) 12)

(else (* 6 3)))

18

(cond ((equal? 8 3) (+ 3 8))

((equal? 8 8) 12)

(else (* 6 3)))

12

(cond ((equal? 3 3) (+ 3 8))

((equal? 3 8) 12)

(else (* 6 3)))

11

-> cond function equates to a conditional in other languages, as we switch the values of 16 we see the return values change. This is due to the cond function moving down the body of the code and checking for equality, what is returned is respectively the value after the condition.

Part 5: Defining functions

1. In a new file, enter in the following code, save it, then run it.

```
(lambda (x)
  (+ x 1))
```

What does Racket return? -> #<procedure:...1-local/lab1.rkt:2:0>

The `lambda` function is an anonymous *function*. In this case, you have defined an anonymous function that takes a parameter `x` and adds 1 to it. Functions are also called *procedures*.

Without parameter(s), the above function cannot do much. It can be used this way by given arguments:

```
((lambda (x)
  (+ x 1)) 3)
```

Run this, and give the result.

Answer:

((lambda (x)

(+ x 1)) 3)

4

2. Define named functions:

```
(define add-one
  (lambda (x)
    (+ x 1)))
```

Save this code to a file called "`add-one.rkt`", run it, then type (add-one 5) in the interactions window. The `define` statement created a *pointer*, called `add-one`, which points to the function you just created. Run this, and give the result.

Run the following, and give the result. Does it serve the same purpose as the previous one?

```
(define (add-one x)
    (+ x 1))
```

Answer:

(add-one 5)

6

(define (add-one x)

(+ x 1))

-> define-values: assignment disallowed;

cannot re-define a constant

constant: add-one

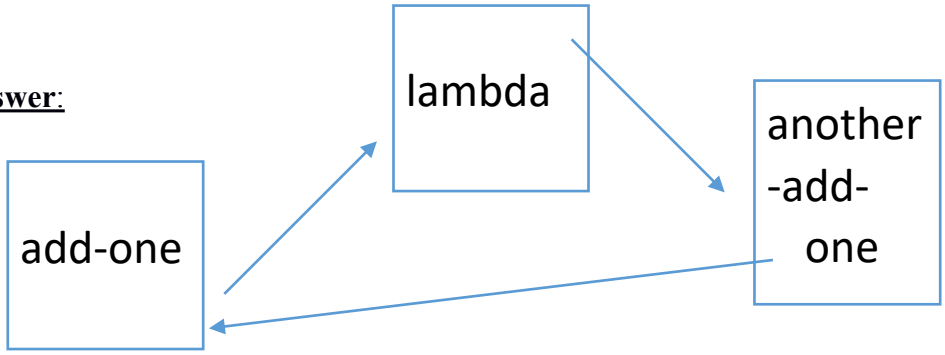
Doesn't serve the same purpose as we need the lambda function.

3. Add the following lines in the same file and run it. Given the result.

```
(define another-add-one add-one)
(another-add-one 5)
```

At the pointer level, what is happening here? Draw a picture in the answer box indicating what is happening.

Answer:



6 is returned.

At the pointer level, we first define add-one and respectively add our lambda function. After moving down the code, we define another-add-one which points back to the original 'add-one' function. We then call another-add-one which adds 1 to 5, returning 6.

4. You can declare "local" variables in Racket via the use of the `let` function. For example, try the following code:

```
(define a 2);;binding a variable to a value
(define b 3)
(define c 4)
(define (strange x)
    (let ((a 1) (b 2))
      (+ x a b)))
```

After executing this code, what are the values of a, b, and c? What is the return value when you make the call `(strange 4)`? Explain your answers.

Answer:

After executing the code; a is 1, b is 2, and c remains 4.

(strange 4)

7

4 is put into the x condition, and then 4 + 3 is evaluated, thus giving us 7 for our answer. We could call (strange c) and this would give us 7 as well.

Useful Reference links:

- https://courses.cs.washington.edu/courses/cse341/12au/racket/basics.html
- https://docs.racket-lang.org/reference/index.html