

## CS 3721: Programming Languages Lab

Lab #05 Solutions: *eval* expression

**Due date: February 26, 3:30pm.** At the beginning of the next recitation.

Goals of this lab:

- More practice with recursion
  - Learn how to use *eval* expression
1. Write a Scheme function *code-modifier* that takes three arguments, two atoms *a*, and *b*; and a list *expr* that holds an expression. Your function should evaluate to a list which holds another expression such that all occurrence(s) of the first atomic argument, *a*, is/are replaced with the second atomic argument, *b*. You can use the following *atom?* function that we had defined in lab2 as a helper function.

```
(define atom? (lambda (x)
                (and (not (null? x))
                     (not (pair? x)))))
```

Examples:

```
(code-modifier '3 '7 '(* 3 (+ 3 5))) => (* 7 (+ 7 5))
(code-modifier '+ '* '(lambda (x) (+ x x))) => (lambda (x) (* x x))
```

**Solution:**

```
(define code-modifier (lambda (a b expr)
  (cond
    ((null? expr) '()) ; base case
    ((atom? expr) (if (eqv? a expr) b expr)) ; base case
    (else
     (let ((x (code-modifier a b (car expr)))
           (y (code-modifier a b (cdr expr))))
       (cons x y))))))
```

2. *eval* expression. (Switch to "Standard (R5RS)" language since *eval* expression is not defined in "Intermediate Student with lambda". In DrScheme environment, Click Language -> choose Language -> Standard (R5RS).)

*Syntax:*

```
(eval expression)
```

Evaluates *expression* and returns its value. *expression* must be a valid Scheme expression represented as data such as a list.

Examples:

```
(eval '( * 7 (+ 7 5) ))  
=> 84
```

```
(let ((f (eval '(lambda (g x) (g x x)))))  
  (f * 5)) ; let body  
=> 25
```

What do the following expressions evaluate to? Please, fill in the blanks.

```
(eval '(- 7 12 5))           => _-10_  
(eval (cons '- '(7 12 5)))   => _-10_  
(eval (cons '- (cdr '(7 12 5)))) => __7__
```

Following expressions evaluate to 13, and 15, respectively. However, the expressions are not complete. Please, fill in the missing code.

```
(eval (cons '+ (cons (eval '(+ 3 4)) (cons (eval '(* 2 3)) _'(_)_)))) => 13  
(eval (cons '+ (cons (eval '(* 2 3)) (cons (eval '(+ 3 4)) _'(2)_)))) => 15
```

Now, using the *eval* expression, and your *code-modifier* function, write an expression that modifies the expression, (lambda (x y) (+ x y)) to (lambda (x y) (\* x y)) and evaluates this modified function with the arguments 3, and 5. The result should be 15. (*Hint:* Think about building a convenient expression before passing it to the *eval* expression as an argument.)

**Solution:**

```
(eval (cons (code-modifier '+ '* '(lambda (x y) (+ x y))) '(3 5)))
```