

# CMPT 383 Midterm 1, Fall 2019

<b>Last name</b> <i>exactly as it appears on student card</i>									
<b>First name</b> <i>exactly as it appears on student card</i>									
<b>SFU Student #</b>									
<b>SFU email</b> <i>ends with sfu.ca</i>									

This is a **closed book exam**: notes, books, computers, calculators, electronic devices, etc. are **not permitted**. Do not speak to any other students during their exam or look at their work. If you have a question, please remain seated and raise your hand and a proctor will come to you.

	<b><i>Out of</i></b>	<b><i>Your Mark</i></b>
<i>Racket and EBNF</i>	15	
<i>You Be the Interpreter!</i>	10	
<i>Short Answer</i>	10	
<b>Total</b>	<b>35</b>	

### Racket and EBNF

Consider the following Racket-like language for prefix expressions involving just + and \*. Both + and \* have exactly 2 arguments, and numbers and symbols (as permitted by Racket's `number?` and `symbol?` functions) are considered legal expressions. Here are some example expressions:

Legal	Not Legal
4.5	"4.5"
cat	(cat)
(+ 4 -2)	(+ 4)
(* a (* 2 2))	(a * (* 2 2))
(+ (* a b) (+ 4 mouse))	(+ 2 (* a b) (+ 4 mouse))

We'll call this language **AM** for short.

a) (5 marks) Write an **EBNF grammar** that describes the syntax of **AM**. Use the Go-style EBNF notation as used in lectures and in the notes.

b) (10 marks) Write a Racket function called `(am-eval e)` that evaluates any valid **AM** expression `e`. If `e` doesn't contain any variables, then return the number that it evaluates to. If `e` contains one, or more, variables, then return the symbol `'unknown`. You can assume `e` is a valid **AM** expression.

For example:

```
> (am-eval '(+ (* 2 3) (+ 4 5)))  
15  
  
> (am-eval '(+ (* 2 3) (+ (* 4 y) 5)))  
'unknown
```

You can use any standard Racket functions, and you can write helper functions if needed. In addition to correctness, the following will also be considered by the markers:

- Is the syntax correct? Are relevant language features used appropriately?
- Is there any unnecessary code?
- Is the code readable? For example, is standard Racket-style indentation and spacing used?

### You Be the Interpreter!

(10 marks) For each of the following Racket expressions, write down on the right what that expression on the left evaluates to when it is typed into the DrRacket interpreter. If something other than a value is returned, then describe what happens using one or two words (e.g. for an error you can write “error”).

<code>(- (+ 10 1 2) (* 2 1 0) 2)</code>	
<code>(rest (rest (first '((1 2) (3) (4 5 6)))))</code>	
<code>(cons (list (+ 5 2)) '(a b))</code>	
<code>(cons 'a (append '(b) (cons 'c '())))</code>	
<code>(let ([a 3] [b 3]) (+ (if (&lt; a b) 1 2) (if (&gt; a b) 3 4)))</code>	
<code>(apply map (list even? '(5 6 7 8)))</code>	
<code>((lambda (x) (cons x `(list ,x))) 'a)</code>	
<code>(apply (first '(+ *)) '(1 2 3))</code>	
<code>(foldr append '() (map list '(a b c)))</code>	
<code>((lambda (x) (x x)) (lambda (x) (x x)))</code>	

### Short Answer

a) (2 marks) Describe in brief, clear English the difference between calling a *function* and calling a *macro* in Racket.

b) (1 mark) Name two different standard Racket forms that are macros.

c) (1 mark) Racket's macros are *hygienic*. What does that mean?

d) Consider the following code:

```
(define x 1)
(define f (lambda (x) (g 3)))
(define g (lambda (y) (+ x y)))
```

i) (1 mark) Using *static scoping*, what does `(f 6)` evaluate to?

ii) (1 mark) Using *dynamic scoping*, what does `(f 6)` evaluate to?

e) (2 marks) Write a *continuation passing style (CPS)* version of Racket's `cons` function called `cons-c`.

f) (2 marks) Implement the `(curry3 f)` function that returns the *curried* version of any 3-argument function `f`.

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