BBM 301 - Programming Languages - Fall 2020 Midterm
December 1, 2020 – Part 2

Name: _____

Student ID number: _____

Please write your name, ID and following honor pledge:
"**On my honor, I pledge that I have neither given nor received any unauthorized assistance on this exam.** "
and **sign** your answer sheet.

Question 3 - 32 points, 25 mins.

3- BNF for simple Scheme

a) **[10 points]** A list in a functional programming language is either an empty list or a list of elements which are either atoms or other lists. A list is enclosed in parentheses and elements of the list are separated with spaces. Assume that atoms are represented by single upper case letters. Some possible lists are

```
(P Q)
((X Y) Z)
()
(((A B C) (D E)) F (G H))
```

Write a grammar using the BNF to describe such lists. Do not use EBNF notation.

b) **[22 points]** Write rules in BNF to describe a grammar for a simplified Scheme that includes only the limited set of constructs listed below. Do not use EBNF notation.

- numbers
- names
- parameters
- primitive numeric functions : +, −, *, /, MIN, MAX, and SQRT.
- function QUOTE
- list functions CAR and CDR
- lambda expressions
- function definition using DEFINE

Be sure that your grammar accepts the following example expressions:

```
(+ 3 4 5)
(- 20 (* 4 2))
(MIN 5 3 4)
(LAMBDA (x) (+ x 1))
(LAMBDA (a b c) (+ (* a a) (* b b) c))
(DEFINE pi 3.14)
(DEFINE fun (LAMBDA (x) (+ x 1)))
(QUOTE (1 2 3))
(CAR (QUOTE (2 3 4)))
(CDR (QUOTE (2 3 4)))
(DEFINE hypotenuse (LAMBDA (a b) (SQRT (+ (* a a) (* b b))) ) )
```

```
(DEFINE second (LAMBDA (lst) (CAR (CDR lst)) ) )
```