Concordia University
Department of Computer Science and Software Engineering
COMP 348: Principles of Programming Languages
Winter 2020
Assignment 2
Evaluation: 100 pts

Due date and time: Before Sunday March 8, 2020 at 23:59

Note: For this assignment, you can make use of all the in-built **predicate** functions like oddp, evenp, atom, etc. However, you can't use any other utility functions such as length of list. You may need to use the "member" function in Question 3, description is available at: http://clhs.lisp.se/Body/f_mem_m.htm

Question 1 (15 pts)

Write a lisp function `triangle` that takes an argument `(n)` and shows a triangle of printed numbers as shown in the following samples. If the input is decimal or string, it should print an appropriate message.

`(triangle 4)`

```
1
1 2
1 2 3
1 2 3 4
```

`(triangle 5)`

```
1
1 2
1 2 3
1 2 3 4
1 2 3 4 5
```

`(triangle 2.5)` → `decimal numbers are not valid input, please enter an integer`

Question 2 (15 pts)

Write a Lisp program that calculates the distance between two arbitrary points `P1:(x1 y1)` and `P2:(x2 y2)` based on the following formula.

$$distance\ (P1, P2) = \sqrt{(x1 - x2)^2 + (y1 - y2)^2}$$

Implement your program in two different ways:

1- Using anonymous function (lambda)

2- Without applying the anonymous function.

Which method is more efficient in terms of memory allocation?

Question 3 (15 pts)

Write a lisp function that accepts a list as the input argument (the list is mixed up integers, decimals, characters and nested lists) and creates a list including all the characters in the original list without any duplication. Sample program output is shown below:

1. '((z f) (b a 5 3.5) 6 (7) (a) c) → (z f b a c)
2. '((n) 2 (6 h 7.8) (w f) (n) (c) n) -> (h w f c n)

Question 4 (10 pts)

Write a Lisp function `f-l-swap` that swaps the first and last elements of a list.

Sample Output:

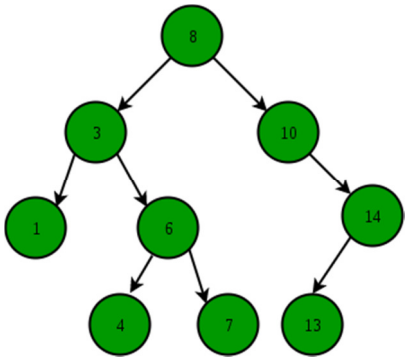
(f-l-swap '((a d) f 10 w h)) → (h f 10 w (a d))

(f-l-swap '(g 6 p 10 m)) → (m 6 p 10 g)

Question 5 (15 pts)

Write a lisp program to check whether a binary tree is a Binary Search Tree. A Binary Search Tree (BST) is a tree in which all the nodes follow the below-mentioned properties:

- The left sub-tree of a node has a key less than or equal to its parent node's key.
- The right sub-tree of a node has a key greater than to its parent node's key.



Example of a binary search tree

A list can be used to represent the structure of a binary tree as follow:

```
'(8 (3 (1 () ()) (6 (4 () ())( 7 () ()))) (10 (()) (14 (13) ())))
```

Question 6 (20 pts)

Write a lisp program to compute the series for the sin(x) and cos(x) depending on the value of *n*. The function takes 2 arguments (*x* and *n*) and based on the value of *n* calculates one of the following functions:

sin-cos-comp (x, n) =

$$\begin{cases} \sin(x) = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \cdots + \frac{x^n}{n!} & \textbf{-10 < x < 10, n is odd} \\ \cos(x) = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \cdots + \frac{x^n}{n!} & \textbf{n is even} \end{cases}$$

You are not allowed to use any inbuilt functions except predicate functions to check value type. Your program should print an appropriate message for string and decimal values for *n.* Additionally, there is a limit for *x* when *n* is an odd number.

Question 7 (20 pts)

In mathematics, the **Pell numbers** are an infinite sequence of integers, that comprises the denominators of the closest rational approximation to the square root of 2. The sequence of approximations begins with

$$\frac{1}{1} \quad \frac{3}{2} \quad \frac{7}{5} \quad \frac{17}{12} \quad \frac{41}{29} \quad \ldots.$$

So the sequence of **Pell numbers** begin with 1, 2, 5, 12, 29,…. . The Pell numbers are defines as follow:

$$P_n = \begin{cases} \mathbf{0} \quad \boldsymbol{if\ n = 0} \\ \mathbf{1} \quad \boldsymbol{if\ n = 1} \\ \mathbf{2}p_{n-1} + p_{n-2} \quad \boldsymbol{otherwise} \end{cases}$$

Writ a lisp program that computes the **Pell numbers** for an input argument `n` using:

a) An iterative approach
b) A recursive approach

For example `pellnumbers (6)` should return a list `(0 1 2 5 12 29 70)`

Write at least 2 test cases for each version (a and b).

Submission:

- **Assignment must be done individually (no groups are permitted).**
  - Create one zip file, containing all files for your assignment.
  - Name your zip file this way:*a1_studentID*, where *studentID* is your ID number, for the first assignment, student 123456 would submit a zip file named a1_123456.zip
- Assignments must be submitted through Moodle.

> **Note**: **Assignment not submitted by the due date and in the correct format will not be graded – NO EXCEPTIONS!!!!**