NATIONAL UNIVERSITY OF SINGAPORE

CS1101S — PROGRAMMING METHODOLOGY

AY2022/2023 SEMESTER 1

READING ASSESSMENT 2

Time Allowed: **45 Minutes**

INSTRUCTIONS

1. This assessment contains **21 Multiple-Choice Questions** in **3 Sections**.

2. Each question has one correct answer. The **indicated marks** are awarded for each correct answer and there is **no penalty** for a wrong answer.

3. The full score of this assessment is **60 marks**.

4. Answer **all questions**.

5. This is a **Closed-Book** assessment, but you are allowed one double-sided **A4 / letter-sized sheet** of handwritten or printed **notes**.

6. You are allowed to use up to **4 sheets** of **blank A4 / letter-sized** paper as **scratch paper**.

7. You are allowed access to these online reference pages:
   - **Source §3 pre-declared constants and functions** at https://docs.sourceacademy.org/source_3/global.html
   - **Specification of Source §3** at https://docs.sourceacademy.org/source_3.pdf

8. **Follow the instructions of your invigilator or the module coordinator to submit your answers**.

Pre-declared Functions

In this assessment, you are allowed access to these online reference pages:

- **Source §3 pre-declared constants and functions** at https://docs.sourceacademy.org/source_3/global.html
- **Specification of Source §3** at https://docs.sourceacademy.org/source_3.pdf

For this **entire assessment**, the following implementations for the pre-declared functions **`map`**, **`filter`**, **`accumulate`**, and **`append`** **supersede** the implementations given in the **Specification of Source §3** at https://docs.sourceacademy.org/source_3.pdf.

```
function map(f, xs) {
    return is_null(xs)
           ? xs
           : pair(f(head(xs)), map(f, tail(xs)));
}

function filter(pred, xs) {
    return is_null(xs)
           ? null
           : pred(head(xs))
           ? pair(head(xs), filter(pred, tail(xs)))
           : filter(pred, tail(xs));
}

function accumulate(f, initial, xs) {
    return is_null(xs)
           ? initial
           : f(head(xs), accumulate(f, initial, tail(xs)));
}

function append(xs, ys) {
    return is_null(xs)
           ? ys
           : pair(head(xs), append(tail(xs), ys));
}
```

Section A [16 marks]

For all the questions in this section, consider the following Source program:

Program X:

```
let w = 2;

function gee() {
    {
        let w = 3;
    }
    let hoo = x => (y => 100 * w + 10 * x + y);
    w = 4;
    return hoo;
}

{
    let w = 5;
}

w = 6;
gee()(7)(8);
```

(1) **[4 marks]** What is the result of evaluating Program X?

- **A.** 278
- **B.** 378
- **C.** 478
- **D.** 578
- **E.** 678
- **F.** 587
- **G.** 687
- **H.** None of the other options is the correct answer

(2) **[3 marks]** How many **environment frames** get created during the evaluation of Program X? (Do not count the global environment frame.)

- **A.** 1
- **B.** 2
- **C.** 3
- **D.** 4
- **E.** 5
- **F.** 6
- **G.** 7
- **H.** None of the other options is the correct answer

(3) **[3 marks]** Of the **environment frames** that get created during the evaluation of Program X, how many **extend the program environment *directly***?

A. 1
B. 2
C. 3
D. 4
E. 5
F. 6
G. 7
H. None of the other options is the correct answer

(4) **[3 marks]** How many **function objects** get created during the evaluation of Program X? (Do not count function objects of primitive and pre-declared functions.)

A. 0
B. 1
C. 2
D. 3
E. 4
F. 5
G. 6
H. None of the other options is the correct answer

(5) **[3 marks]** In the environment frame that has the binding for name **`gee`**, what is the value of the binding for name **`w`** at the end of the evaluation of Program X?

A. 2
B. 3
C. 4
D. 5
E. 6
F. 7
G. 8
H. None of the other options is the correct answer

Section B [24 marks]

For all the questions in this section, consider the following Source program:

Program Y:

```
function something(xs, ys) {
    function swap_pair(p, q) {
        let head_p = head(p);
        let tail_p = tail(p);
        set_head(p, head(q));
        set_tail(p, tail(q));
        set_head(q, head_p);
        set_tail(q, tail_p);
    }
    if (!is_null(xs)) {
        swap_pair(xs, ys);
        something(tail(xs), tail(ys));
    }
}
let AA = list(list(11), list(22), list(33), list(44));
let BB = list(list(55), list(66), list(77), list(88));
let AA0 = AA;
let AA0_head = head(AA0);
let AA0_tail = tail(AA0);
let AA1 = tail(AA);
let AA1_head = head(AA1);
let AA1_tail = tail(AA1);
something(AA, BB);
```

(6) **[3 marks]** What is the value of `AA` (in *list notation*) at the end of the evaluation of Program Y?

A. `list(list(11), list(22), list(33), list(44))`
B. `list(list(55), list(66), list(77), list(88))`
C. `list(list(11), list(66), list(33), list(88))`
D. `list(list(55), list(22), list(77), list(44))`
E. `list(list(11), list(66), list(77), list(88))`
F. `list(list(55), list(22), list(33), list(44))`
G. None of the other options is the correct answer

(7) **[3 marks]** What is the result of the following statement if it is evaluated at the end of Program Y?

```
[ AA0 === AA,  AA0_head === head(AA),  AA0_tail === tail(AA) ];
```

A. [false, false, false]
B. [false, false, true]
C. [false, true, false]
D. [false, true, true]
E. [true, false, false]
F. [true, false, true]
G. [true, true, false]
H. [true, true, true]

(8) **[3 marks]** What is the result of the following statement if it is evaluated at the end of Program Y?

```
[ AA1 === tail(AA),
  AA1_head === head(tail(AA)),
  AA1_tail === tail(tail(AA)) ];
```

A. [false, false, false]
B. [false, false, true]
C. [false, true, false]
D. [false, true, true]
E. [true, false, false]
F. [true, false, true]
G. [true, true, false]
H. [true, true, true]

(9) **[2 marks]** How many **pairs** get created during the evaluation of Program Y?

A. 4
B. 8
C. 12
D. 16
E. 20
F. 24
G. 32
H. None of the other options is the correct answer

(10) **[2 marks]** How many **bindings** does the **program environment frame** contain during the evaluation of Program Y?

A. Fewer than 8
B. 8
C. 9
D. 10
E. 11
F. 12
G. 13
H. More than 13

(11) **[4 marks]** How many **environment frames** get created during the evaluation of Program Y? (Do not count the global environment frame. We assume that the applications of the primitive functions, such as `is_null`, `head`, `tail`, `pair`, `list`, `set_head`, and `set_tail`, do not create any frame.)

A. 6
B. 10
C. 14
D. 15
E. 17
F. 19
G. 20
H. None of the other options is the correct answer

(12) **[2 marks]** Of the **environment frames** that get created during the evaluation of Program Y, how many **extend the program environment *directly***? (We assume that the applications of the primitive functions do not create any frame.)

A. 5
B. 9
C. 13
D. 14
E. 16
F. 18
G. 19
H. None of the other options is the correct answer

(13) **[3 marks]** How many **function objects** get created during the evaluation of Program Y? (Do not count function objects of primitive and pre-declared functions such as `array_length`, `math_floor`, `pair`, `head`, `tail`, `length`, and `map`.)

A. 0
B. 1
C. 4
D. 5
E. 6
F. 7
G. 9
H. None of the other options is the correct answer

(14) **[2 marks]** Of the **function objects** that get created during the evaluation of Program Y, how many have the **program environment as their environment** (i.e. their right circles point to the program frame)? (Do not count function objects of primitive and pre-declared functions.)

A. 0
B. 1
C. 4
D. 5
E. 6
F. 7
G. 9
H. None of the other options is the correct answer

Section C [20 marks]

For all the questions in this section, consider the following Source program:

Program Z:

```
function what(rows) {
    let M = [];
    let rr = 0;

    while (rr < rows) {
        M[rr] = [];
        let cc = 0;

        while (cc <= rr ) {
            if ( cc % 2 === 0 ) {
                M[rr][cc] = () => 10 * rr + cc;
            } else {
                let temp = 10 * rr + cc;
                M[rr][cc] = () => temp;
            }
            cc = cc + 1;
        }
        rr = rr + 1;
    }

    return M;
}

let AA = what(7);
```

(15) **[3 marks]** What is the result of the following statement if it is evaluated at the end of Program Z?

```
AA[4][1]();
```

A. 41
B. 40
C. 77
D. 47
E. 71
F. 45
G. 75
H. None of the other options is the correct answer

(16) **[3 marks]** What is the result of the following statement if it is evaluated at the end of Program Z?

```
AA[4][2]();
```

A. 42
B. 41
C. 77
D. 47
E. 71
F. 45
G. 75
H. None of the other options is the correct answer

(17) **[3 marks]** How many **arrays** get created during the evaluation of Program Z?

A. 1
B. 6
C. 7
D. 8
E. 9
F. 28
G. 29
H. None of the other options is the correct answer

(18) **[3 marks]** How many **environment frames** get created during the evaluation of Program Z? (Do not count the global environment frame.)

A. 3
B. 10
C. 15
D. 17
E. 22
F. 31
G. 38
H. None of the other options is the correct answer

(19) **[2 marks]** Of the **environment frames** that get created during the evaluation of Program Z, how many have bindings for the variable `cc`?

A. 1
B. 4
C. 6
D. 7
E. 8
F. 12
G. 28
H. None of the other options is the correct answer

(20) **[2 marks]** Of the **environment frames** that get created during the evaluation of Program Z, how many have bindings for the variable `temp`?

A. 0
B. 1
C. 6
D. 7
E. 8
F. 12
G. 28
H. None of the other options is the correct answer

(21) **[4 marks]** How many **function objects** get created during the evaluation of Program Z? (Do not count function objects of primitive and pre-declared functions.)

A. 1
B. 7
C. 8
D. 12
E. 13
F. 29
G. 50
H. None of the other options is the correct answer

——— END OF QUESTIONS ———