

NATIONAL UNIVERSITY OF SINGAPORE
CS1101S — PROGRAMMING METHODOLOGY

(AY2019/2020 SEMESTER 1)

READING ASSESSMENT 2, REDACTED EDITION OF 2020/21

Time Allowed: **40 Minutes**

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ANSWERS

INSTRUCTIONS

1. This question paper comprises **NINE (9)** printed pages, including this page.
2. You are also provided with **one OCR Form** to write your answers.
3. Clearly **write** and **shade** your **STUDENT NUMBER** in **SECTION B** of your **OCR Form** using a **2B PENCIL**.
4. You do not need to write in **SECTION A** of your **OCR Form**.
5. There are **17** multiple-choice questions. Each question has one correct answer. **1 mark** is awarded for each correct answer and there is no penalty for a wrong answer.
6. The full score is **17 marks**.
7. Answer **ALL** questions.
8. Use only a **2B PENCIL** to **shade** your answers on your **OCR Form**.
9. This is a **CLOSED BOOK** assessment, but you are allowed to bring in one A4 sheet of notes (handwritten or printed on both sides).
10. **Submit only the OCR Form.**

- (1) What is the single-digit **number** at the **top-right corner** on the **front page** of this question paper? (**Important:** Please make sure your answer is correct because it determines how we mark your answers to all the subsequent questions.)

- A. 1 **(answer)**
- B. 2
- C. 3
- D. 4
- E. 5

- (2) What is the order of growth of the *runtime* of the following function in terms of N using the Θ notation? Note that N is a non-negative integer value.

```
function funX(N) {
    let sum = 0;
    for (let x = 1; x <= N; x = x + 1) { sum = sum + 1; }
    for (let y = 2 * N; y >= 1; y = y - 1) { sum = sum + 1; }
    return sum;
}
```

- A. $\Theta(1)$
- B. $\Theta(N)$ **(answer)**
- C. $\Theta(N^2)$
- D. $\Theta(N^3)$
- E. None of the above

- (3) What is the order of growth of the *runtime* of the following function in terms of N using the Θ notation? Note that N is a non-negative integer value.

```
function funY(N) {
    let sum = 0;
    for (let x = 1; x <= N; x = x + x) {
        for (let y = 1; y <= N; y = y + 2) {
            sum = sum + 1;
        }
    }
    return sum;
}
```

- A. $\Theta(1)$
- B. $\Theta(\log N)$
- C. $\Theta(N)$
- D. $\Theta(N \log N)$ **(answer)**
- E. $\Theta(N^2)$

- (4) What is the order of growth of the *runtime* of the following function in terms of N using the Θ notation? Note that N is a non-negative integer value.

```
function funZ(N) {
  let sum = 0;
  for (let i = 0; i <= 1024*N; i = i + (N / 2)) {
    sum = sum + 1;
  }
  return sum;
}
```

- A. $\Theta(1)$ **(answer)**
- B. $\Theta(\log N)$
- C. $\Theta(N)$
- D. $\Theta(N \log N)$
- E. $\Theta(N^2)$

- (5) The *runtime* of Program P has order of growth $\Theta(g(n))$. Which of the following is correct?

- A. Its order of growth in *space* is $\Theta(g(n))$.
- B. Its order of growth in *space* is $\Omega(g(n))$.
- C. Its order of growth in *space* is $O(g(n))$. **(answer)**
- D. Its order of growth in *space* is $\Theta(n)$.
- E. None of the above.

- (6) What is the sequence of values printed by the `display` function when the following program is evaluated?

```
function d(m, x) {
  display(m);
  return x;
}
const w = d("5", 5);
d("F", x => d("+", d("w", w) + d("x", x)) ) (d("8", 8));
// same as (x => w + x)(8)
```

- A. "5" "F" "+" "w" "x" "8"
- B. "5" "w" "x" "+" "F" "8"
- C. "5" "F" "w" "x" "+" "8"
- D. "5" "8" "w" "x" "+" "F"
- E. "5" "F" "8" "w" "x" "+" **(answer)**

Consider the following Source program for the next 4 questions:

Program A:

```
function g(x) {
  function g(x) {
    function g(x) {
      return (x <= 3) ? 34 : g(x - 3);
    }
    return (x <= 2) ? 23 : g(x - 2);
  }
  return (x <= 1) ? 12 : g(x - 1);
}
const x = g(10);
(x => x)(x);
```

- (7) During the evaluation of Program A, how many names does the program environment frame contain?
- A. 0
 - B. 1
 - C. 2 **(answer)**
 - D. 3
 - E. More than 3
- (8) How many environment frames get created during the evaluation of Program A? (Do not count the global environment frame.)
- A. 9 **(answer)**
 - B. 7
 - C. 6
 - D. 5
 - E. None of the above
- (9) Of the environment frames that get created during the evaluation of Program A, how many extend the program environment *directly*?
- A. 1
 - B. 2 **(answer)**
 - C. 3
 - D. 4
 - E. More than 4
- (10) How many function objects get created during the evaluation of Program A?
- A. 1
 - B. 2
 - C. 3
 - D. 4 **(answer)**
 - E. More than 4

Consider the following Source program for the next 3 questions:

Program B:

```
function F(xs) {
  if (is_null(tail(xs))) {
    return xs;
  } else {
    const v = F(tail(xs));
    return pair(head(v), pair(head(xs), tail(v)));
  }
}
const L = list(1, 2, 3);
const R = F(L);
R;
```

- (11) How many environment frames get created during the evaluation of Program B? (Do not count the global environment frame. We assume that the application of a primitive function does not create any frame. See Appendix for a list of primitive functions.)
- A. 6 **(answer)**
 - B. 5
 - C. 4
 - D. 3
 - E. None of the above
- (12) Of the environment frames that get created during the evaluation of Program B, how many extend the program environment *directly*?
- A. 5
 - B. 4
 - C. 3 **(answer)**
 - D. 2
 - E. None of the above
- (13) How many pairs get created during the evaluation of Program B?
- A. 3
 - B. 5
 - C. 6
 - D. 7 **(answer)**
 - E. None of the above

Consider the following Source program for the next 4 questions:

Program C:

```
function H(n) {
  let M = [];
  let i = 1;
  while (i <= n) {
    const f = x => x + i;
    M[i - 1] = f;
    i = i + 1;
  }
  return M;
}
const M = H(4);
let sum = 0;
let i = 0;
while (i < 4) {
  sum = sum + M[i](0);
  i = i + 1;
}
sum;
```

(14) What is the value of sum at the end of the evaluation of Program C?

- A. 6
- B. 10
- C. 15
- D. 16
- E. 20 (answer)

(15) How many environment frames get created during the evaluation of Program C? (Do not count the global environment frame.)

- A. 2
- B. 3
- C. 6
- D. 10
- E. None of the above (answer)

(16) Of the environment frames that get created during the evaluation of Program C, how many extend the program environment *directly*?

- A. 1 (answer)
- B. 2
- C. 5
- D. 9
- E. None of the above

(17) How many function objects get created during the evaluation of Program C?

- A. 1
- B. 4
- C. 5 (answer)
- D. 9
- E. None of the above

————— END OF QUESTIONS —————

Appendix

Primitive Functions

The following are some of the primitive functions in Source §3:

- `display(a)`
- `pair(x, y)`
- `is_pair(x)`
- `head(x)`
- `tail(x)`
- `is_null(xs)`
- `list(x1, x2, ..., xn)`
- `set_head(p, x)`
- `set_tail(p, x)`
- `array_length(x)`

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