Solved.

CS1101S Programming Methodology

Reading Assessment 2, redacted version of 2020/21

Use **only** the given answer sheet to indicate your answer to each of the following 13 questions. Use a pencil, and mark only one choice for each question. Do not write your name, but only your student number, on the answer sheet.

The paper ends on page 7. Pages 8 and 9 are empty. Feel free to tear off these sheets and use them as scratch paper.

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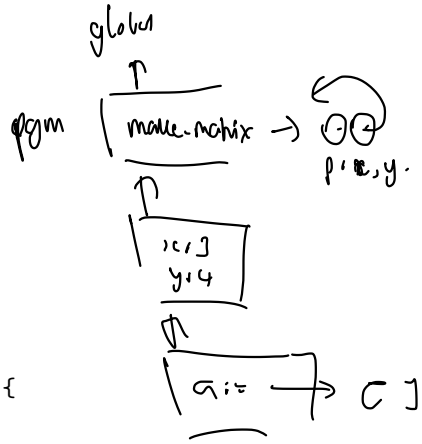


Part A

Consider the following Source program:

```
function make_matrix(x, y) {
    let a = [];
    for (let i = 0; i < x; i = i + 1) {
        a[i] = [];
        for (let j = 0; j < y; j = j + 1) {
            a[i][j] = 0;
        }
    }
    return a;
}

make_matrix(3,4);
```

Question 1: How many arrays get created, when this program runs?

1 [A] 1

1 [B] 4

1 [C] 12

1 [D] 81

1 [E] none of the above

Question 2: How many array assignments (assigning a value at a particular index in an array) are carried out during the evaluation of the program above?

2 [A] 3

2 [B] 4

2 [C] 12

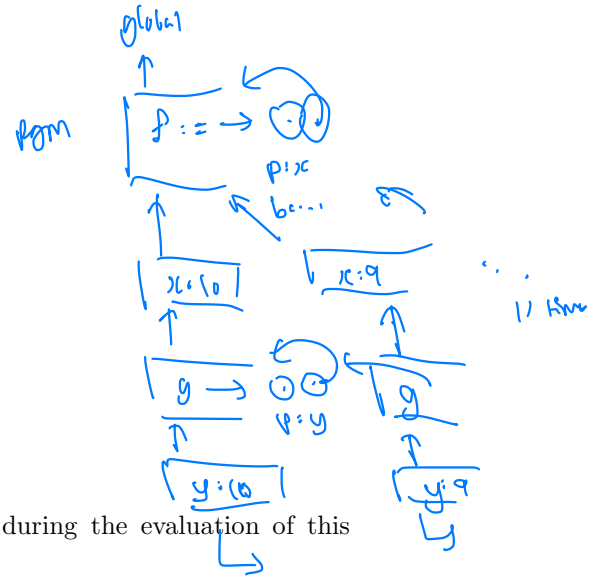
2 [D] 64

2 [E] none of the above

Part B

Consider the following Source program:

```
function f(x) {
    function g(y) {
        return (y === 0) ? x : f(y - 1);
    }
    return g(x);
}
f(10);
```



Question 3: How many environment frames get created during the evaluation of this program, excluding the global frame?

3 [A] 4

3 [B] 12

3 [C] 23

3 [D] 34

3 [E] none of the above

Question 4: How many function objects get created during the evaluation of this program?

4 [A] 2

4 [B] 12

4 [C] 23

4 [D] 34

4 [E] none of the above

Question 5: Some of the environment frames will contain the variable `g`. Which variable do these frame also contain?

5 [A] `x`

5 [B] `y`

5 [C] `f`

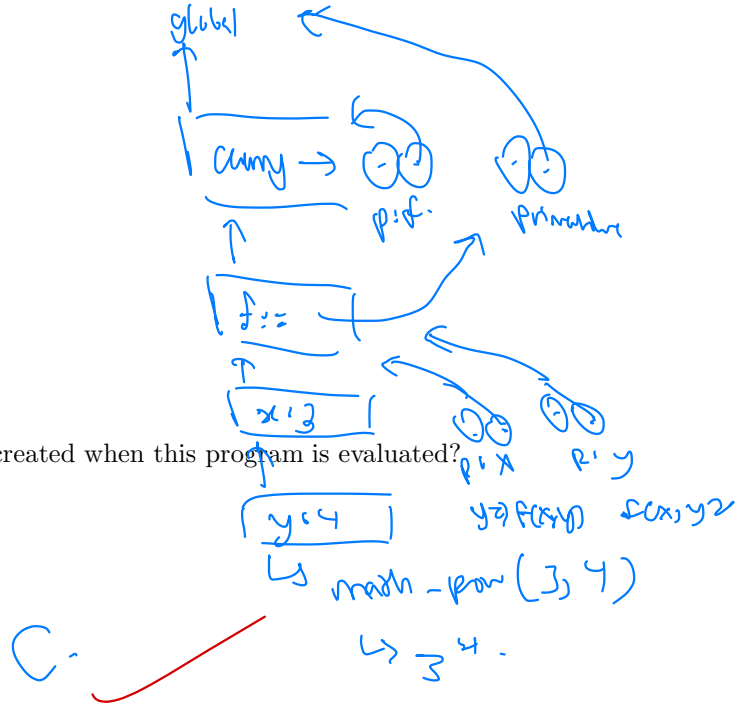
5 [D] `display`

5 [E] none of the above

Part C

Consider the following program.

```
function curry(f) {
    return x => y => f(x, y);
}
curry(math_pow)(3)(4);
```



Question 6: How many function objects get created when this program is evaluated?

6 [A] 0

6 [B] 1

6 [C] 3

6 [D] 5

6 [E] none of the above

Question 7: One of the environment frames that get created will contain the variable `f`. Which variable does this frame also contain?

7 [A] `x`

7 [B] `y`

7 [C] `curry`

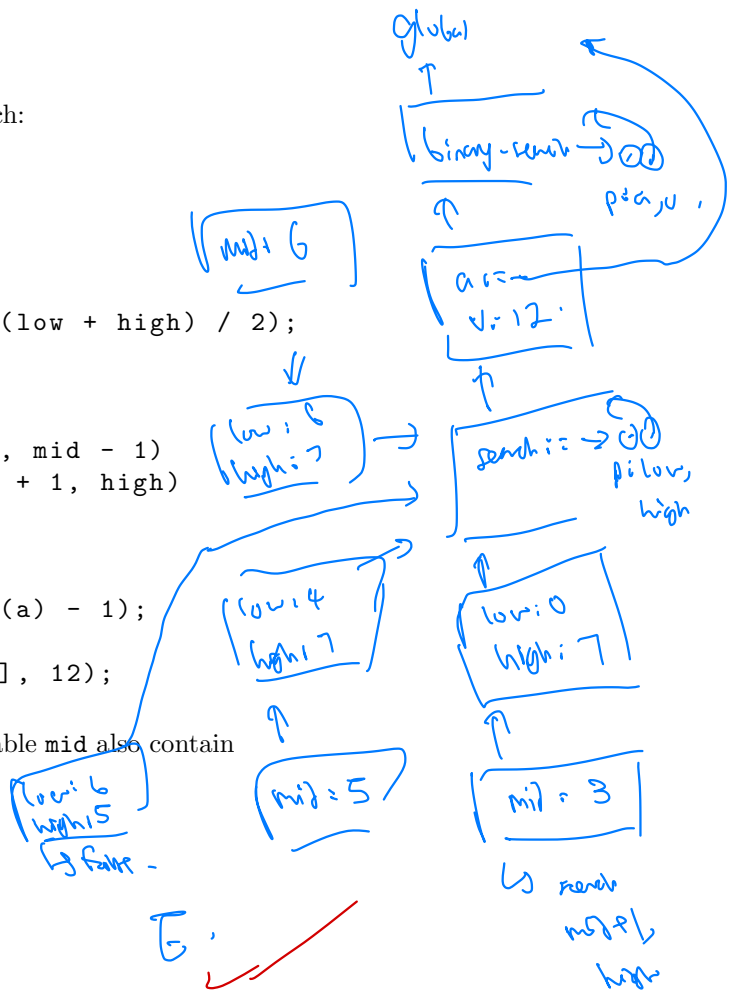
7 [D] `math_pow`

7 [E] none of the above

Part D

Consider the following program for binary search:

```
function binary_search(a, v) {
    function search(low, high) {
        if (low > high) {
            return false;
        } else {
            let mid = math_floor((low + high) / 2);
            return (v === a[mid])
                   ||
                   ( (v < a[mid])
                     ? search(low, mid - 1)
                     : search(mid + 1, high)
                   );
        }
    }
    return search(0, array_length(a) - 1);
}
binary_search([1,3,5,7,9,11,13,15], 12);
```



Question 8: The frames that contain the variable `mid` also contain

8 [A] the variables `low, high`

8 [B] the variables `a, v`

8 [C] the variable `binary_search`

8 [D] the variable `search`

8 [E] none of the above

Question 9: How many times will the function `search` be called during the evaluation of this program?

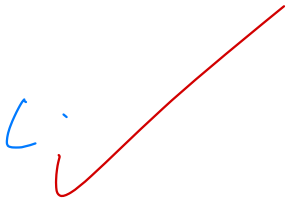
9 [A] twice

9 [B] 3 times

9 [C] 4 times

9 [D] 5 times

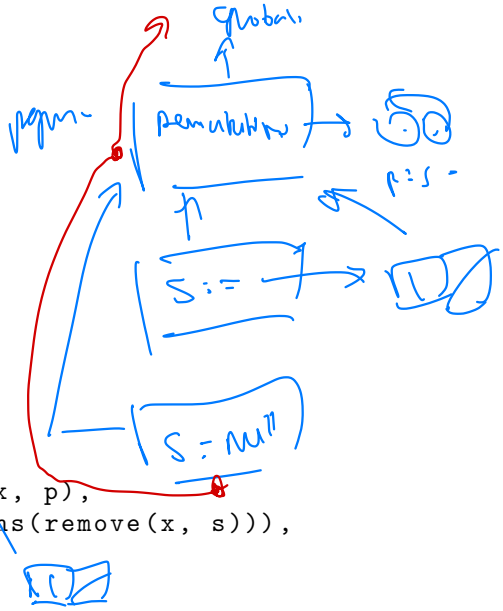
9 [E] none of the above



Part E

Consider the following program from the lectures.

```
function permutations(s) {
    return is_null(s)
        ? list(null)
        : accumulate(
                  append, null,
                  map(x =>
                        map(p => pair(x, p),
                            permutations(remove(x, s))),
                      s));
}
permutations(list(1));
```



Question 10: According to the environment model, the evaluation of a variable requires a lookup of the variable in the innermost frame of the current environment. If the lookup fails, the innermost frame of the *enclosing* environment is used, and so on until the global environment is reached. When evaluation reaches the expression `pair(x, p)` during the evaluation of the program, the variable `pair` is looked up in frame(s). How many frame lookups will fail, before the value of `pair` is found in the global frame?

10 [A] 1

10 [B] 2

10 [C] 3

10 [D] 4

10 [E] none of the above

Question 11: How many function objects get created during the evaluation of the program?

11 [A] 1

11 [B] 3

11 [C] 5

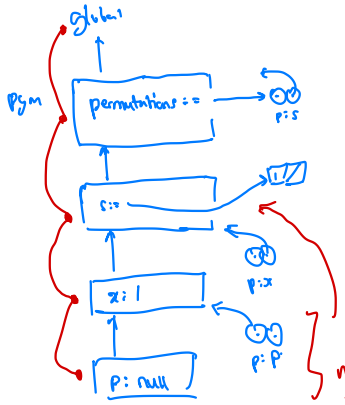
11 [D] 6

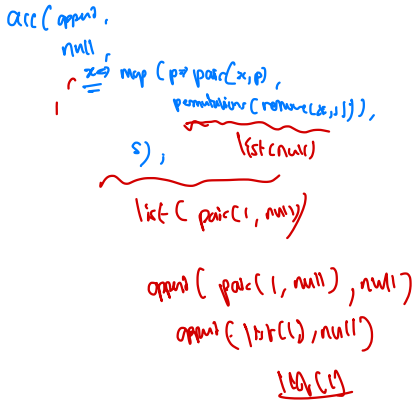
11 [E] none of the above

— END OF QUESTIONS —

Scratch Paper

```
function permutations(s) {
    return is_null(s)
        ? list(null)
        : accumulate(
                  append, null,
                  map(x =>
                        map(p => pair(x, p),
                            permutations(remove(x, s))),
                      s));
}
permutations(list(1));
```





∴ 4 failed frames.

not sure, shouldn't this be attached to the prev frame?

Scratch Paper

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Part A

Consider the following Source program:

```
function make_matrix(x, y) {
    let a = [];
    for (let i = 0; i < x; i = i + 1) {
        a[i] = [];
        for (let j = 0; j < y; j = j + 1) {
            a[i][j] = 0;
        }
    }
    return a;
}

make_matrix(3,4);
```

Question 1: How many arrays get created, when this program runs?

1 [A] 1

1 [B] 4

1 [C] 12

1 [D] 81

1 [E] none of the above

Answer: B: The matrix, and its three rows.

Question 2: How many array assignments (assigning a value at a particular index in an array) are carried out during the evaluation of the program above?

2 [A] 3

2 [B] 4

2 [C] 12

2 [D] 64

2 [E] none of the above

Answer: E: 15 (12 array assignments in the inner loop and 3 assignments in the outer loop)

Part B

Consider the following Source program:

```
function f(x) {
    function g(y) {
        return (y === 0) ? x : f(y - 1);
    }
    return g(x);
}
f(10);
```

Question 3: How many environment frames get created during the evaluation of this program, excluding the global frame?

3 [A] 4

3 [B] 12

3 [C] 23

3 [D] 34

3 [E] none of the above

Answer: D: The correct number of environment frames for this program is 34.

Question 4: How many function objects get created during the evaluation of this program?

4 [A] 2

4 [B] 12

4 [C] 23

4 [D] 34

4 [E] none of the above

Answer: B: 12 (11 function objects for function `g` and and one for function `f`)

Question 5: Some of the environment frames will contain the variable `g`. Which variable do these frame also contain?

5 [A] `x`

5 [B] `y`

5 [C] `f`

5 [D] `display`

5 [E] none of the above

Answer: E: none of the above

Part C

Consider the following program.

```
function curry(f) {
    return x => y => f(x, y);
}
curry(math_pow)(3)(4);
```

Question 6: How many function objects get created when this program is evaluated?

6 [A] 0

6 [B] 1

6 [C] 3

6 [D] 5

6 [E] none of the above

Answer: C: 3

Question 7: One of the environment frames that get created will contain the variable `f`. Which variable does this frame also contain?

7 [A] `x`

7 [B] `y`

7 [C] `curry`

7 [D] `math_pow`

7 [E] none of the above

Answer: E: That frame only has variable `f`

Part D

Consider the following program for binary search:

```
function binary_search(a, v) {
    function search(low, high) {
        if (low > high) {
            return false;
        } else {
            let mid = math_floor((low + high) / 2);
            return (v === a[mid])
                   ||
                   ( (v < a[mid])
                     ? search(low, mid - 1)
                     : search(mid + 1, high)
                   );
        }
    }
    return search(0, array_length(a) - 1);
}
binary_search([1,3,5,7,9,11,13,15], 12);
```

Question 8: The frames that contain the variable `mid` also contain

8 [A] the variables `low, high`

8 [B] the variables `a, v`

8 [C] the variable `binary_search`

8 [D] the variable `search`

8 [E] none of the above

Answer: E: There is a frame for just the alternative statement of the conditional.

Question 9: How many times will the function `search` be called during the evaluation of this program?

9 [A] twice

9 [B] 3 times

9 [C] 4 times

9 [D] 5 times

9 [E] none of the above

Answer: C: 4 times (arguments: 0,7; 4,7; 6,7; 6,5)

Part E

Consider the following program from the lectures.

```
function permutations(s) {
    return is_null(s)
        ? list(null)
        : accumulate(
                    append, null,
                    map(x =>
                          map(p => pair(x, p),
                              permutations(remove(x, s))),
                        s));
}
permutations(list(1));
```

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10 [A] 1

10 [B] 2

10 [C] 3

10 [D] 4

10 [E] none of the above

Answer: D: 4 (one frame with `p`, one with `x`, one with `s`, and one with `permutations`)

Question 11: How many function objects get created during the evaluation of the program?

11 [A] 1

11 [B] 3

11 [C] 5

11 [D] 6

11 [E] none of the above

Answer: B: 3 (each function expression/statement gives rise to one function object, here)

— END OF QUESTIONS —

Scratch Paper

Scratch Paper