

# Midterm Exam - Programming Language Theory

Computer Science and Engineering - SeoulTech

**October 21, 2020**

Student ID: \_\_\_\_\_

Name: \_\_\_\_\_

Question	Points
Q1	
Q2	
Q3	
Q4	
Q5	
Q6	
Total	

## Instructions

- There are **3 pages of questions** in total. Please check you get all the pages before starting the exam.
- Do not forget to **write your Student ID and Name** above.
- You have **2 hours for 6 questions with 100 points** in total.
- You can write your answers either in English or Korean. However, please use English for technical terms and names (e.g., BNF, Best Fit, dynamic scope, etc.) as you have learned in lectures, to avoid any confusions.
- Please write your answers in neat and tidy handwriting. If your answers are unrecognizable, they will be marked as incorrect regardless of their correctness.
- If boxes are too small, you can mark it with numbers and write your answer with the numbers in other spaces near the boxes.

---

**Question 1 (10pt).** Please answer the following questions by either fill in the blanks, or write a simple sentence.

(a) (2pt) An interpreter repeats the three tasks, which are known as   
-  -  -*Loop*, in short, REPL.

(b) (2pt) A system is , if it can be used to simulate a Turing Machine.

(c) (2pt) What is a set of bindings at a specific point in the program at run-time?

(d) (4pt) Write a prefix expression equivalent to a mathematical equation  $a - 5 \times (b - c)$ . Your answer must be evaluated in the same order as the given equation (i.e.,  $b - c$  is computed first).

**Question 2 (20pt).** Euclidean algorithm is an algorithm to compute the Greatest Common Divisor (GCD) of two integers  $a$  and  $b$ ,  $a > b$ . We can denote GCD of  $a$  and  $b$  as  $\text{gcd}(a, b)$ . Then,  $\text{gcd}(a, b)$  satisfies the condition that,  $\text{gcd}(a, b) = \text{gcd}(b, r)$  if  $a \% b = r$  and  $r \neq 0$ .

**(a) Recursion (10pt).** Complete the following recursive function which computes  $\text{gcd}(a, b)$  for two integers  $a, b$ . You can assume that  $a > b$  is guaranteed.

```
1 int gcd(int a, int b) {  
2     if(  ) {  
3         return  ;  
4     } else {  
5         return  ;  
6     }  
7 }
```

**(b) Tail-Recursion (10pt).** Is your answer in the previous question **tail-recursive**? Please also explain why your function is tail-recursive or not.

---

**Question 3 (20pt).** Define a language  $L$  generated by the given context-free grammar  $G$ , by completing the conditions.

$$G = (\{S, A, B\}, \{a, b\}, S, P),$$

$$S \rightarrow Ab|aB$$

$$A \rightarrow aaA|\varepsilon,$$

$$B \rightarrow Bbb|\varepsilon.$$

$$L(G) = \{a^n b^m : \boxed{\phantom{000000}} \text{ or } \boxed{\phantom{000000}} \}$$

(a):

(b):

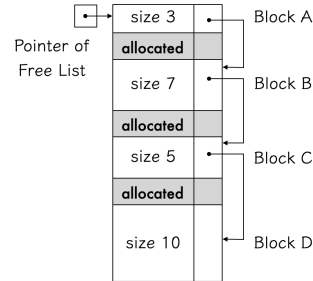
**Question 4 (15pt).** Consider the following code written in SEOULTECH, a new programming language. SEOULTECH employs *dynamic scope with shallow binding*. This language can pass functions as parameters, global variables are handled statically regardless of its location, and its programs start from the function `PL()`. `global` and `local` keywords indicate global and local variables respectively. `print(x)` prints `x` to the console. What is the output of the given code and why? You can give the reason by specifying actual values of expressions.

```

1  global x = 2;
2  func f(k) {
3      return x+k;
4  }
5  func foo(g) {
6      local x = 5;
7      return x + g(1);
8  }
9  func bar(h, m) {
10     return h(f) + m;
11 }
12 func PL() {
13     print(bar(foo, 1));
14 }
```

Write answer here.

**Question 5 (15pt).** This image shows the heap dynamically managed with variable length block method. Currently there are four free blocks Blocks A (size 3), B (size 7), C (size 5) and D (size 10), in the order attached in the free list. Now, answer the following questions. Note that (a)'s allocation doesn't affect to (b).



**(a) First Fit (5pt).** Suppose we are using *First Fit* strategy. When there is a memory request of size 4, which free block will be allocated?

**(b) Best Fit (5pt).** Suppose we are using *Best Fit* strategy. When there is a memory request of size 4, which free block will be allocated?

**(c) Discussion (5pt).** What are the (1) advantage and (2) disadvantage of Best Fit compared to First Fit? State your answer simply like “Best Fit is better to ...”

(1):

(2):

**Question 6 (20pt).** Here is an image of Central Referencing Table (CRT) with a hidden stack to implement dynamic scope. On the left side, Blocks A, B, C and D are presented, and they are executed in that sequence. Fill in the blanks if necessary, to simulate dynamic scope implementation with CRT in this execution. When you fill the hidden stack, fill it from the bottom, since it is a “stack”. Note that some of the blanks should be empty.

Block Execution												
A: { x, y = ... B: { v, w = ... } C: { w, x = ... D: { y = ... } } //end of C } //end of A	A			AB			ABC			ABCD		
	x	1	a1	x	1	a1	x			x		
	y	1	a2	y	1	a2	y			y		
	v	0		v	1	b1	v			v		
	w	0		w	1	b2	w			w		