Data Structure Midterm Examination
3:30pm-5:20pm (110 minutes), April. 17, 2017

#: _____ Student ID: _____ Name: _____

- ✧ 看清題目再作答。
- ✧ 中英文、鉛筆原子筆做答都可以。
- ✧ Please answer **questions 1 - 5 on the question sheet**. For other questions, please answer on the answer sheet in any order you want.
- ✧ There are 9 questions. You can obtain up to 114 points.

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1. **(12pt)** Please analyze the **time complexity** of the following algorithms

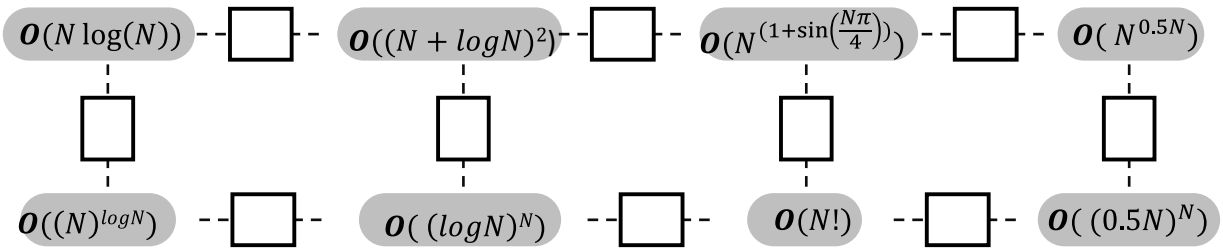
```
for (int i=0; i<N; i++)
  for (int j=0; j<i*i; j++)
    for (int k=1; k<j; k=k*2)
      print("Hello");
```

Ω(**)** **O(** **)**

```
x = 2; y = 2;
while (x<N) {
  j = random 0 or 1;
  if (j == 0 && y<x) {
    y=y+1;
  }else{
    x=x*x;
  }
}
```

Ω(**)** **O(** **)**

2. **(15pt)** Please fill out the boxes with "=", "<", or ">" to show the asymptotic complexity hierarchy. For example, **O**(n^2) < **O**(n^3) = **O**(n^3/10).



3. **(12pt)** Please complete the following **recursive function** that **recursively divides an array into two halves** (i.e., 遞迴二分法) to find the maximum value in the array.

Please also show the **time complexity** using 1) a recursive definition and 2) a closed-form θ notation.

```
int RMAX(int array[], int size)
{
   int m;
   
   return m;
}
```

your code goes here

(1) T(size) = **(2)**

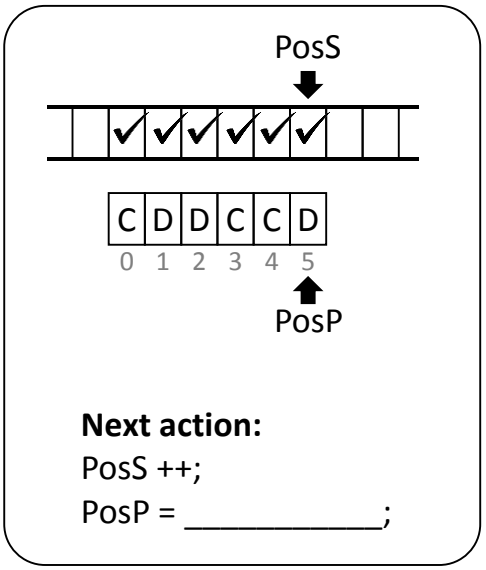
➔ **T(size) = θ(_____)**

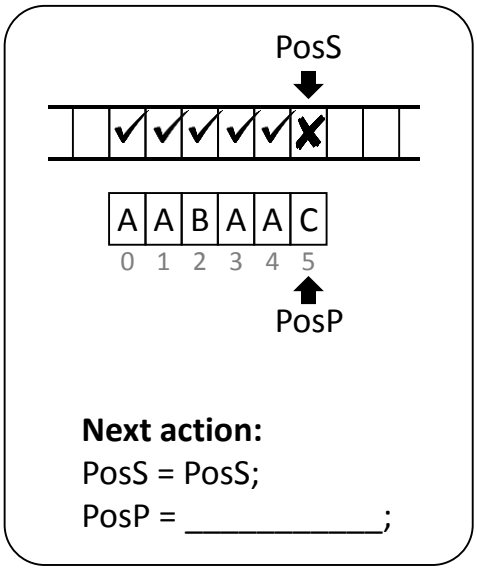
4. KMP algorithm

(1) **(7pt)** Please show the 0-based failure function of the following patterns.

S	D	T	D	S	S	D	T	D	S	S	x
0											_____ if x == '**D**' _____ if x == '**S**' _____ if x == '**T**' _____ otherwise

(2) **(8pt)** What is the next PosP index (0~5)? A check mark (✓) stands for a match, and a cross mark stands for a mismatch.





5. **(12pt)** Please convert **A || (A + B * C % 9) < D == T && B** into a postfix expression.

Only the four boxes with thick borders will be graded (只有粗黑框格子計分).

bottom

Token	Stack	Output So Far
A		
||		
(		
A		
+		
B		
*		
C		
%		
9		
)		
<		
D		
==		
T		
&&		
B		
	Final output	

Priority	Operator
High	In-coming (
	*, /, %
	+, -
	<, <=, >=, >
	==, !=
	&&
	||
Low	In-stack (

------ 以下請於答案卷作答 **Answer the following questions on the answer sheet** ------

6. **(12pt) Asymptotic notations**

$$\big(F(N)+G(N)\big)=\boldsymbol{O}(N!)\ \Rightarrow \big(F(N)\times G(N)\big)=\boldsymbol{O}((2N)!)$$

(1) **(4pt)** Is the above statement **true or false**?

(2) **(8pt)** Please prove your answer **according to the definition of Big-O**.

Hint: $\frac{x+y}{2}\geq\sqrt{xy}$

7.

(1) **(4pt)** What are the three basic structures of **structured programming**?

(2) **(4pt)** To solve a problem, a structured program can always achieve **the same or better speed** than a non-structured program can. Is this statement **true or false**? Please briefly explain.

(3) **(4pt)** Can the access levels of object members affect the function of a program? Why don't we always use *public*?

8. **(12pt)** We want to design a data structure to store an lower-triangular matrix (LTM). The following figure shows a 3x3 LTM example.

$$\begin{bmatrix} T_{00} & 0 & 0 \\ T_{10} & T_{11} & 0 \\ T_{20} & T_{21} & T_{22} \end{bmatrix}$$

T_{00}	T_{10}	T_{11}	T_{20}	T_{21}	T_{22}
0	1	2	3	4	5

(1) **(4pt)** How many integers are exactly needed for an NxN LTM if only the triangular part is stored in a 1-D array, row by row, as shown above?

(2) **(4pt)** Following the above question, let f(i, j) be the array index of term T_{ij}. Please show f(i, j).

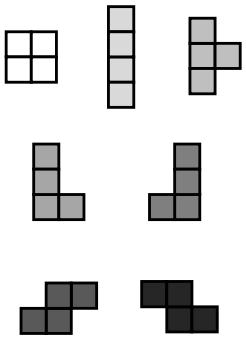
(3) **(4pt)** Let **R** be the probability that $T_{ij} = 0$. If a data structure treats a LTM as a **sparse matrix** and stores only non-zero terms, how many integers are exactly needed for an NxN LTM?

9. **(12pt)** Please design a simple Tetris (俄羅斯方塊) game. The skeleton code is shown below. **Make reasonable assumptions and simplification** yourself if appropriate. Please write C/C++ style pseudo code and focus on the following two functions.

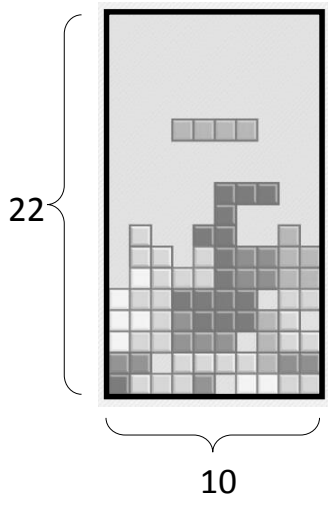
   (1) **(6pt) Tetromino::tryMove( )** which tries to move the incoming tetromino piece, updates the tetromino's (x, y) coordinates, and returns whether the movement is successful.

   (2) **(6pt) Playground::tryClearLines( )** which calculates how many horizontal lines on the playground are full, clears full lines, and moves other lines downward.

Tetromino



Playground




```
class Playground;

class Tetromino{
friend class Playground;
    Tetromino();
    void reset(); // reset x, and y.  randomize type.
    int tryMove(int direction, const Playground & pg);
                  // 0: cannot move, 1: successfully move
private:
    int type;     // 1~7 for the seven types
    int x, y;     // Tetromino's position in the playground
    int score;
};

class Playgrond{
friend class Tetromino;
    Playground();
    void fix(const Tetromino & t); // fix the tetromino
    int tryClearLines();
    void draw(const Tetromino & curr_tetromino);
    void addScore(int s);
private:
    int grid[10][22];  // 0 for empty.  1~7 for tetrominos
};

int main()
{
  Tetromino t;
  Playground pg;
  While(1){
    int k = GetKey();  // LEFT, RIGHT, DOWN, or NONE
    if(k == NONE) {  k = DOWN; }
    if(k == DOWN && t.tryMove(k, pg) == 0) {
        pg.fix(t);
        pg.addScore(pg.tryClearLines());
        t.reset();
    }else{
        pg.draw(t);
    }
    sleep(0.5);  // sleep 0.5 second
  }
}
```