

Paper 1 (Compulsory Part) 卷一（必答部分）

	Format 類型	# Questions 題目數	Total Marks 佔分
Section A 甲部	Multiple Choice 多項選擇題	10	10
Section B 乙部	Short Questions 短答題	6 (A - F)	9
Section C 丙部	Long Questions 長填充題	2 (G - J)	6
Total 總分			25

- (1) The term “arrays” in Paper 1 generally refers to lists in Python.

卷一提及的「陣列」泛指 Python 語言的串列。

- (2) The following code is added to the beginning of all C++ programs.

在所有 C++ 程序的頂部加入以下程式碼：

C++

```
#include <algorithm>
#include <array>
#include <cmath>
#include <cstdlib>
#include <deque>
#include <forward_list>
#include <iostream>
#include <list>
#include <queue>
#include <stack>
#include <string>
#include <utility>
#include <vector>
using namespace std;
```

- (3) Assume all programs shall be compiled and executed in Debian 12 using the compilers and commands below.

假設所有程序都將在 Debian 12 下使用以下編譯器及指令進行編譯，然後執行。

GNU G++ (g++-12 12.2.0)

```
g++ -std=c++20 program.cpp -o program
./program
```

Python 3 (python3.11 3.11.2)

```
python3.11 -S -m py_compile program.py
python3.11 -O -S program.py
```

Section A 甲部 (10 marks 分)

For each question, choose the **most appropriate** answer and mark the corresponding box (A, B, C, or D) on the answer sheet. One mark for each correct answer. No marks will be deducted for wrong answers.

請為下列每題各選一個**最適合**的答案，然後把答題紙對應的空格（A、B、C、或 D）填滿。
答對得一分，答錯不扣分。

1. There are some cards on the table. After reading both faces of the cards, Alice made the following conclusion:
桌子上有一些卡片。閱讀這些卡片的兩面後，愛麗絲得出了以下結論：

“If the card shows “HKOI” on one face, it shows “Fun” on the other.”

「如果卡片的一面顯示 “HKOI”，那麼另一面顯示 “Fun” 。」

Which of the following cards could possibly be on the table?

以下哪一些卡片可能在桌子上？

	Facing Up 面朝上	Facing Down 面朝下
i.	Bad	HKOI
ii.	IOI	Fun
iii.	Difficult	NOI

- A. ii only 只有 ii
B. iii only 只有 iii
C. i and ii only 只有 i 和 ii
D. ii and iii only 只有 ii 和 iii
2. What is the output of the following program? 以下程序的輸出是什麼？

Python

```
print(123 % (10 ^ 2) // 10)
```

C++

```
int main() {  
    cout << 123 % (10 ^ 2) / 10;  
}
```

- A. 0
B. 1
C. 2
D. 3

3. What is the output of the following program? 以下程序的輸出是什麼？

Python

```
s = "HKOI"
cur = ""
ans = ""

for c in s:
    cur += c
    ans += cur

print(ans)
```

C++

```
int main() {
    string s = "HKOI";
    string cur = "";
    string ans = "";
    for (auto c : s) {
        cur += c;
        ans += cur;
    }
    cout << ans;
}
```

- A. HHHH
B. HKOI
C. HKOIKOIOII
D. HHKHKOHKOI
4. Which of the following statements is true? 以下哪項敘述為真？
- A. Linear search requires the array to be sorted before it can be performed.
線性搜尋需要將陣列排序後才能執行。
- B. Linear search checks each element sequentially until a match is found or the entire array has been checked.
線性搜尋依次檢查每個元素，直到找到匹配項或整個陣列已檢查完畢。
- C. Binary search splits the array into two halves, then performs linear search on both halves in parallel.
二分搜尋將陣列分成兩半，然後在兩半上並行地執行線性搜尋。
- D. Binary search only works on arrays whose lengths are powers of 2.
二分搜尋只適用於長度為 2 的幕次的陣列。
5. Given two Boolean variables X and Y. Which of the following statements are true?
給定兩個布爾變量 X 及 Y。以下哪些敘述為真？
- i. $((X \text{ AND } Y) \text{ AND } ((\text{NOT } X) \text{ AND } (\text{NOT } Y)))$
The Boolean expression always evaluate to false. 此布爾表達式總是運算為假。
- ii. $((X \text{ AND } (\text{NOT } X)) \text{ OR } (\text{NOT } Y))$
The Boolean expression always evaluate to true. 此布爾表達式總是運算為真。
- iii. $((X \text{ OR } Y) \text{ OR } (X \text{ OR } (\text{NOT } Y)))$
The Boolean expression always evaluate to true. 此布爾表達式總是運算為真。
- A. i and ii only 只有 i 和 ii
B. i and iii only 只有 i 和 iii
C. ii and iii only 只有 ii 和 iii
D. i, ii and iii i、ii 和 iii

6. Which of the following statements about data structures are true?

以下哪些關於數據結構的說法是正確的？

- i. Four integers, 3, 1, 4, 5 are pushed into an empty stack in this order. The top of the stack is 3.
四個整數 3、1、4、5 依此順序推入一個空堆疊（棧）中。堆疊的頂部是 3。
- ii. Four integers, 3, 1, 4, 5 are pushed into an empty queue in this order. The front of the queue is 3.
四個整數 3、1、4、5 依此順序推入一個空隊列中。隊列的前端是 3。
- iii. Traversing a singly linked list passes through four integers 3, 1, 4, 5 in this order. The head of the linked list points to the node with value 3.
遍歷一個單向鏈表會按此順序經過四個整數 3、1、4、5。鏈表的頭指向值為 3 的節點。

- A. i and ii only 只有 i 和 ii
- B. i and iii only 只有 i 和 iii
- C. ii and iii only 只有 ii 和 iii
- D. i, ii and iii i、ii 和 iii

7. What is the output of the following program? 以下程序的輸出是什麼？

Python

```
s = "2024-11-09"
count = 0

for c in s:
    for d in s:
        if c == d:
            count += 1
print(count)
```

C++

```
int main() {
    string s = "2024-11-09";
    int count = 0;
    for (char c : s)
        for (char d : s)
            if (c == d)
                count += 1;
    cout << count;
}
```

- A. 8
- B. 14
- C. 16
- D. 18

8. There is a stone pile with n stones initially. Alice and Bob take turns to take stones from the pile and Alice moves first. If the person in the previous turn took x stones, the person in this turn can take x or $x + 1$ stones. The first person who cannot take the required amount of stones loses. Alice goes first and removes 1 stone. In which of the following situations will Bob have a winning strategy?

起初石堆中有 n 顆石頭。愛麗絲和鮑伯輪流從石堆中拿走石頭，愛麗絲先走。如果前一輪的人拿了 x 顆石頭，這輪的人可以拿 x 或 $x + 1$ 顆石頭。最先無法拿走所需數量的石頭的人輸。愛麗絲先走並取走 1 顆石頭。在下列哪一種情況下，鮑伯會有獲勝的策略？

- i. $n = 5$
- ii. $n = 6$

- A. i only 只有 i
- B. ii only 只有 ii
- C. i and ii only 只有 i 和 ii
- D. None of them 無

9. You start with a string with only one character S. In each step, you could perform one of the following actions:
你起初會有一個字串，字串僅有一個字符 S。每步你可以執行以下其中一個行動：

1. Replace an S with aSb.
用 aSb 取代一個 S。
2. Replace an S with bSa.
用 bSa 取代一個 S。
3. Remove an S from the string.
移除一個 S。

Which of the following strings can be produced by the above actions?

以下哪些字串可以用以上行動產生？

- i. aaaabbbb
- ii. aaabbaabbb
- iii. abaaaaaaba

- A. i and ii only 只有 i 和 ii
B. i and iii only 只有 i 和 iii
C. ii and iii only 只有 ii 和 iii
D. i, ii and iii i、ii 和 iii

10. Suppose function `flip()` randomly returns one of two outcomes: 0, 1 uniformly and independently. After running the program segment below, which of the following statements must be true?

假設函數 `flip()` 會以相等的概率隨機和獨立地傳回 0 或 1。在執行以下程序段之後，以下哪項敘述必定為真？

Python

```
x = 0
x += flip() + flip() + flip()
for i in range(10):
    if flip() == 0:
        x += flip() * flip() * flip()
```

C++

```
int x = 0;
x += flip() + flip() + flip();
for (int i = 0; i < 10; ++i) {
    if (flip() == 0) {
        x += flip() * flip() * flip();
    }
}
```

- i. After running the program segment above, x is at most 3.
在執行以上程序段之後，x 最大為 3。
- ii. After running the program segment above, x can be 33.
在執行以上程序段之後，x 可以為 33。
- iii. After running the program segment above, x is a multiple of 3.
在執行以上程序段之後，x 是 3 的倍數。

- A. i only 只有 i
B. ii only 只有 ii
C. iii only 只有 iii
D. None of them 無

END OF SECTION A 甲部完

Section B 乙部 (9 marks 分)

The blanks are labeled from A to F. Please fill in the blanks on the answer sheet.

下列各空格分別命名為 A 至 F，請在答題紙上對應的地方填上答案。

Note 注意：

- (1) You can write only one character in each box on the answer sheet.
答題紙上每個小格只可填上一個字符。
- (2) Answers must not exceed the designated number of boxes.
答案長度不得多於該題提供的小格數目。
- (3) Write legibly. Unrecognizable answers will be regarded as incorrect.
字體須端正清楚，無法辨別之答案當錯誤論。

1. What is the output of the following program? 以下程序的輸出是什麼？

Python

```
a = 2024
b = 2025

if a == b:
    a = b + 1
else:
    a = b

b = a + 1
print(b)
```

C++

```
int main() {
    int a = 2024;
    int b = 2025;
    if (a == b) {
        a = b + 1;
    } else {
        a = b;
    }
    b = a + 1;
    cout << b;
}
```

Answer 答案: A (1.5 marks 分)

2. Complete the program such that it outputs ioi2025.
完成以下程序，使其輸出 ioi2025。

Python

```
s = 'hkoi2024/25'
t = 'hkoi2025/26'
u = '  B  '

if s < u and u < t:
    print("ioi2025")
```

C++

```
int main() {
    string s = "hkoi2024/25";
    string t = "hkoi2025/26";
    string u = "  B  ";
    if (s < u && u < t)
        cout << "ioi2025";
}
```

Answer 答案: B (1.5 marks 分)

3. Two different cards are chosen randomly from 9 cards numbered 1 to 9. Given that the sum of the numbers of the chosen cards is even, what is the probability that both cards are odd-numbered?

從 9 張編號為 1 到 9 的卡片中隨機選擇兩張不同的卡片。已知所選卡片的號碼總和是偶數，這兩張卡片號碼都是奇數的概率是多少？

Answer 答案: C (1.5 marks 分)

4. What is the output of the following program? 以下程序的輸出是什麼？

Python

```
def f() -> bool:
    print("f", end="")
    return False

def g() -> bool:
    print("g", end="")
    return True

def h() -> bool:
    print("h", end="")
    return True

if f() and g() or h():
    print("i", end="")
```

C++

```
bool f() {
    cout << "f";
    return false;
}

bool g() {
    cout << "g";
    return true;
}

bool h() {
    cout << "h";
    return true;
}

int main() {
    if (f() && g() || h()) {
        cout << "i";
    }
}
```

Answer 答案: D (1.5 marks 分)

5. Alice and Bob are standing on an infinitely long number line. The positions on the number line are labelled $\dots, -2, -1, 0, 1, 2, \dots$ from left to right.

愛麗絲和鮑伯站在一條無限長的數線上。數線上的位置由左至右以 $\dots, -2, -1, 0, 1, 2, \dots$ 標示。

Initially, Alice is at position 2024, while Bob is at position 4040. Alice can jump 5 positions to the right each time, while Bob can jump 11 positions to the left each time.

一開始，愛麗絲的位置為 2024，而鮑伯的位置為 4040。愛麗絲每次可以向右跳 5 個位置，而鮑伯每次可以向左跳 11 個位置。

What is the minimum number of jumps made by Alice and Bob in total so that they end up at the same position?
愛麗絲和鮑伯總共最少需要跳多少次才能到達相同位置？

Answer 答案: E (1.5 marks 分)

6. Consider the following program: 考慮以下程序：

Python

```
a = int(input())
ans = 0
i = 0

while i < a:
    ans += 1
    a -= 1
    i += 1

if ans <= 9:
    print("Cool")
else:
    print("Not cool")
```

C++

```
int main() {
    int a;
    cin >> a;
    int ans = 0;
    int i = 0;

    while (i < a) {
        ans += 1;
        a -= 1;
        i += 1;
    }

    if (ans <= 9) {
        cout << "Cool";
    } else {
        cout << "Not cool";
    }
}
```

For how many different integer inputs between 0 and 100 (inclusive) does this program output Cool?

有多少個在 0 和 100 之間（含）的不同整數輸入會使這個程序輸出 Cool？

Answer 答案: F (1.5 marks 分)

END OF SECTION B 乙部完

Section C 丙部 (6 marks 分)

The blanks are labeled from G to J. Please fill in the blanks on the answer sheet.

下列各空格分別命名為 G 至 J，請在答題紙上對應的地方填上答案。

Note 注意：

- (1) You can write only one character in each box on the answer sheet.
答題紙上每個小格只可填上一個字符。
- (2) Answers must not exceed the designated number of boxes.
答案長度不得多於該題提供的小格數目。
- (3) Write legibly. Unrecognizable answers will be regarded as incorrect.
字體須端正清楚，無法辨別之答案當錯誤論。
- (4) If blank X is divided into N parts X1, X2, ..., XN, it means that marks will only be given when X1, X2, ..., XN are all correct.
如果空格 X 分為 N 部份 X1、X2、...、XN，那麼 X1、X2、...、XN 皆為正確才會給分。

1. Given an array a of n unique positive integers.

給定一個包含 n 個正整數的陣列 a ，其中的所有元素都是唯一的。

You are given a function f which, when calling $f(i, j)$ where $0 \leq i, j < n$, the values of $a[i]$ and $a[j]$ will be swapped if and only if $a[i] > a[j]$.

給定一函數 f ，當呼叫 $f(i, j)$ 且 $0 \leq i, j < n$ 時，當且僅當 $a[i] > a[j]$ 時函數會把 $a[i]$ 和 $a[j]$ 的值對調。

- (a) Complete the function g so that array a will be sorted in ascending order after calling $g(n)$.

完成函數 g 使得呼叫 $g(n)$ 後陣列 a 中的元素按遞增排序。

Python

```
def g(n: int) -> None:
    for i in range(n):
        for j in range(n - i - 1):
            f(__G__)
```

C++

```
void g(int n) {
    for (int i = 0; i < n; ++i)
        for (int j = 0; j < n - i - 1; ++j)
            f(__G__);
}
```

Answer 答案: _____ G _____ (1.5 marks 分)

- (b) Complete the function h so that array a will be sorted in ascending order after calling $h(n)$.

完成函數 h 使得呼叫 $h(n)$ 後陣列 a 中的元素按遞增排序。

Python

```
def h(n: int) -> None:
    for i in range(n):
        for j in range(i + 1, n):
            f(__H__)
```

C++

```
void h(int n) {
    for (int i = 0; i < n; ++i)
        for (int j = i + 1; j < n; ++j)
            f(__H__);
}
```

Answer 答案: _____ H _____ (1.5 marks 分)

2. A *perfect grid* is a grid with 3 rows and 3 columns, where each cell in the grid is filled with a **unique** integer between 1 and 9 (inclusive). For example, the following shows a perfect grid:

一個完美網格是一個含有 3 列及 3 欄的網格，而網格中每個格子填上一個在 1 和 9 之間（含）而獨一無二的整數。舉例來說，以下顯示一個完美網格：

9	2	1
6	8	5
7	3	4

(a) Consider the following constraints: 考慮以下約束：

- The sums of the numbers in each row are all equal to X .
每列中數字的和均等於 X 。
- The sums of the numbers in each column are all equal to X .
每欄中數字的和均等於 X 。

It is known that there exists a perfect grid that satisfies all constraints above. Write down a possible value of X .
已知存在符合以上所有約束的完美網格。寫下 X 的一個可能值。

Answer 答案: _____ I _____ (1 mark 分)

(b) Consider the following constraints: 考慮以下約束：

- The sums of the numbers in each row are all equal to Y .
每列中數字的和均等於 Y 。
- The sums of the numbers in each column are all equal to Y .
每欄中數字的和均等於 Y 。
- The sum of numbers on the upper left corner and lower right corner is equal to Z .
左上角和右下角的數字的和等於 Z 。
- The sum of numbers on the upper right corner and lower left corner is equal to Z .
右上角和左下角的數字的和等於 Z 。

It is known that there exists a perfect grid that satisfies all constraints above. Write down a possible value of Z .
已知存在符合以上所有約束的完美網格。寫下 Z 的一個可能值。

Answer 答案: _____ J _____ (2 marks 分)

END OF PAPER 1 卷一完

Paper 2 卷二

Important Instructions 重要指示

- (1) Choose ONE programming language: Python OR C++.
請從 Python 或 C++ 中選擇一款編程語言。
- (2) Indicate your choice by marking the corresponding box on the answer sheet.
將答題紙對應的空格填滿，以表示你的選擇。
- (3) If you choose the Python version, attempt all questions from this page to page 9, and put your answers in the Python sections of the answer sheet.
如選擇 Python 版本，應作答此頁起至第 9 頁之所有題目，並將你的答案填寫在答題紙的 Python 部分。
- (4) If you choose the C++ version, attempt all questions from page 10 to page 18, and put your answers in the C++ sections of the answer sheet.
如選擇 C++ 版本，應作答第 10 至 18 頁之所有題目，並將你的答案填寫在答題紙的 C++ 部分。

Paper 2 卷二 (Python)

	Format 類型	# Questions 題目數	Total Marks 佔分
Section A 甲部	Multiple Choice 多項選擇題	5	5
Section B 乙部	Short Questions 短答題	6 (A - F)	9
Section C 丙部	Long Questions 長填充題	2 (G - K)	6
Total 總分			20

Assume all programs shall be compiled and executed in Debian 12 using the compilers and commands below.
假設所有程序都將在 Debian 12 下使用以下編譯器及指令進行編譯，然後執行。

```
Python 3 (python3.11 3.11.2)
python3.11 -S -m py_compile program.py
python3.11 -O -S program.py
```

Section A 甲部 (5 marks 分)

For each question, choose the **most appropriate** answer and mark the corresponding box (A, B, C, or D) on the answer sheet. One mark for each correct answer. No marks will be deducted for wrong answers.

請為下列每題各選一個**最適合**的答案，然後把答題紙對應的空格（A、B、C、或 D）填滿。

答對得一分，答錯不扣分。

1. Which of the following statements about data types in Python is true?

以下哪個有關 Python 中數據類型的陳述是正確的？

i. `bool` can only hold any one of the three values: `True`, `False`, and `None`.

`bool` 只能儲存 `True`、`False` 和 `None` 這 3 個值中的任意一個。

ii. `str` can only be a sequence of characters of a positive length.

`str` 只能是具有正長度的字符序列。

iii. `float` can be `nan`, which is used to represent a value that is “Not a Number”.

`float` 可以是 `nan`，用於代表「非數字」的值。

- | | | |
|----|--------------|--------|
| A. | i only | 只有 i |
| B. | ii only | 只有 ii |
| C. | iii only | 只有 iii |
| D. | None of them | 無 |

2. What is the output of the following program? 以下程序的輸出是什麼？

Python

```
a = 21 / 5
b = 21 // 5
c = 21 // 5.6
print(a, b, c)
```

- | | |
|----|--------------|
| A. | 4 4 3 |
| B. | 4 21 21 |
| C. | 4.2 4 3.0 |
| D. | 4.2 4.2 3.75 |

3. Consider the following program: 考慮以下程序：

Python

```
print(1e+200 * 1e+200)
```

We may expect the program to output `1e+400`. However, in fact, the program outputs `inf`.

我們可能期望此程序輸出 `1e+400`。但是，實際上，此程序輸出了 `inf`。

This is due to: 這是鑑於：

- | | | |
|----|------------------|------|
| A. | underflow | 下溢出 |
| B. | overflow | 上溢出 |
| C. | precision error | 精度誤差 |
| D. | truncation error | 截斷誤差 |

4. Consider the following program: 考慮以下程序：

Python

```
c = 0
for i in range(20, 5, -3):
    c += 1
print(c)
```

The output of the program is 5. 程序的輸出是 5。

What is the output of the following program? 以下程序的輸出是什麼？

Python

```
c = 0
for i in (20, 5, -3):
    c += 1
print(c)
```

- A. 0
 - B. 1
 - C. 3
 - D. 5
5. What is the output of the following program? 以下程序的輸出是什麼？

Python

```
h = [7, -4, -3, -14, 12]

def g(n: int) -> int:
    return n + h[n % 5]

n = 2025
for i in range(2025):
    n = g(n)
print(n)
```

- A. 1215
- B. 5411
- C. 8104
- D. 16200

END OF SECTION A 甲部完

Section B 乙部 (9 marks 分)

The blanks are labeled from A to F. Please fill in the blanks on the answer sheet.

下列各空格分別命名為 A 至 F，請在答題紙上對應的地方填上答案。

Note 注意：

- (1) Answers must be in Python. Completed programs shall be compiled and executed according to the procedure specified on Page 1.
您必須使用 Python 作答。完成的程序將以第 1 頁之步驟進行編譯及執行。
- (2) You can write only one character in each box on the answer sheet.
答題紙上每個小格只可填上一個字符。
- (3) Answers must not exceed the designated number of boxes.
答案長度不得多於該題提供的小格數目。
- (4) Write legibly. Unrecognizable answers will be regarded as incorrect.
字體須端正清楚，無法辨別之答案當錯誤論。

1. What is the output of the following program? 以下程序的輸出是什麼？

Python

```
a = [1, 2, 3, -4, -5]
ans = 0
for i in range(4, 0, -1):
    ans += a[i]
print(ans)
```

Answer 答案: A (1.5 marks 分)

2. What is the output of the following program? 以下程序的輸出是什麼？

Python

```
tmp = 0
arr = [12, 91, 85, 5, 53, 87, 93, 33, 90, 8]
for i in range(1, 10):
    x = abs(arr[i] - arr[i - 1])
    if x > tmp:
        tmp = x
print(tmp)
```

Answer 答案: B (1.5 marks 分)

3. What is the output of the following program? 以下程序的輸出是什麼？

Python

```
def b(s: list[int]) -> int:
    x = s.pop()
    y = s.pop()
    s.append(x)
    return y

total = 0
s = []
s.append(2)
s.append(14)
s.append(9)
s.append(11)
s.append(16)
total += b(s)
total += b(s)
s.pop()
s.append(7)
while len(s) >= 2:
    total += s.pop()
    b(s)
print(total)
```

Answer 答案: _____ C _____ (1.5 marks 分)

4. Let a be a non-empty list of integers. We merge adjacent equal elements into one, until no adjacent elements are equal. For example, $[1, 2, 2, 3, 3, 3, 1]$ will become $[1, 2, 3, 1]$. Complete the function `find_merged_length` to return the length of the final list.

設 a 為一非空的整數串列。我們把相鄰相同的元素合併為一，直至沒有相鄰元素是相同的。舉例來說， $[1, 2, 2, 3, 3, 3, 1]$ 會變成 $[1, 2, 3, 1]$ 。完成函數 `find_merged_length` 以返回最終串列的長度。

Python

```
def find_merged_length(a: list[int]) -> int:
    n = len(a)
    ans = 1
    for i in range(1, n):
        if ____ D ____:
            ans += 1
    return ans
```

Answer 答案: _____ D _____ (1.5 marks 分)

5. Complete the function `fix_first_char`, so that `fix_first_char(s)` returns string `s`, with the first character of `s` changed to character 'H'.

完成函數 `fix_first_char`，使得 `fix_first_char(s)` 返回字串 `s`，當中 `s` 的第一個字符改為字符 'H'。

Python

```
def fix_first_char(s: str) -> str:
        E    
    return s

print(fix_first_char("KKOI"))      # HKOI
print(fix_first_char("Long Kong")) # Hong Kong
```

Answer 答案: E (1.5 marks 分)

6. Let `a` be a two-dimensional integer list of size $n \times m$, complete the function `f` so that it returns the sum of absolute differences over all pairs of adjacent cell values.

設 `a` 是一個大小為 $n \times m$ 的二維整數串列，完成函數 `f`，使其返回所有相鄰單元格值的絕對差的總和。

For example, for the following 2×2 array,

例如，對於以下的 2×2 陣列，

```
a = [
    [1, 2],
    [3, 4],
]
```

`f(a)` should return $|2 - 1| + |4 - 3| + |3 - 1| + |4 - 2| = 6$.

函數 `f(a)` 應傳回 $|2 - 1| + |4 - 3| + |3 - 1| + |4 - 2| = 6$ 。

Python

```
def f(a: list[list[int]]) -> int:
    n = len(a)
    m = len(a[0])
    ans = 0
    dx = [1, 0, -1, 0]
    dy = [0, 1, 0, -1]

    for i in range(n):
        for j in range(m):
            for k in range(4):
                ni = i + dx[k]
                nj = j + dy[k]
                if         F        :
                    ans += abs(a[i][j] - a[ni][nj])

    return ans // 2
```

Answer 答案: F (1.5 marks 分)

END OF SECTION B 乙部完

Section C 丙部 (6 marks 分)

The blanks are labeled from G to K. Please fill in the blanks on the answer sheet.

下列各空格分別命名為 G 至 K，請在答題紙上對應的地方填上答案。

Note 注意：

- (1) Answers must be in Python. Completed programs shall be compiled and executed according to the procedure specified on Page 1.
您必須使用 Python 作答。完成的程序將以第 1 頁之步驟進行編譯及執行。
- (2) You can write only one character in each box on the answer sheet.
答題紙上每個小格只可填上一個字符。
- (3) Answers must not exceed the designated number of boxes.
答案長度不得多於該題提供的小格數目。
- (4) Write legibly. Unrecognizable answers will be regarded as incorrect.
字體須端正清楚，無法辨別之答案當錯誤論。
- (5) If blank X is divided into N parts $X_1, X_2, \dots, X_N$, it means that marks will only be given when $X_1, X_2, \dots, X_N$ are all correct.
如果空格 X 分為 N 部份 $X_1, X_2, \dots, X_N$ ，那麼 $X_1, X_2, \dots, X_N$ 皆為正確才會給分。

1. Alice wants to check if a list of integers contains all equal elements. She implements this in a few different ways. It is guaranteed that the list **a** has at least one element.

愛麗絲想檢查一個整數串列是否包含全部相同的元素。她用了幾種不同的方式來實現。保證串列 **a** 至少有一個元素。

- (a) Complete the function `check_all_equal1` to return `True` if and only if list **a** contains all equal elements. 完成函數 `check_all_equal1`，當且僅當串列 **a** 包含全部相同的元素時，返回 `True`。

Python

```
def check_all_equal1(a: list[int]) -> bool:
    n = len(a)
    a.sort()
    return ____ G ____
```

Answer 答案: ____ G ____ (1 mark 分)

- (b) Complete the function `check_all_equal2` to return `True` if and only if list **a** contains all equal elements. 完成函數 `check_all_equal2`，當且僅當串列 **a** 包含全部相同的元素時，返回 `True`。

Python

```
def check_all_equal2(a: list[int]) -> bool:
    n = len(a)
    result = True
    for x in a:
        result &= (x == ____ H ____)
    return result
```

Answer 答案: ____ H ____ (1 mark 分)

- (c) Complete the function `check_all_equal3` to return `True` if and only if the list **a** contains all equal elements. 完成函數 `check_all_equal3`，當且僅當串列 **a** 包含全部相同的元素時，返回 `True`。

Python

```
def check_all_equal3(a: list[int]) -> bool:
    n = len(a)
    v = 0
    c = 0
    for x in a:
        if x == v:
            c += 1
        else:
            v = ____ I1 ____
            c = ____ I2 ____
    return c == n
```

Answer 答案: ____ I1 ____ ____ I2 ____ (1 mark 分)

2. You own a small boat. Now, using the boat, you want to transport n boxes identical in size but with different weights across the river.

你有一艘小船。現在，你想利用船將 n 個大小相同，但重量不同的箱子運送過河。

The maximum capacity of the boat is 2 boxes, while the maximum weight the boat can support is w kg. You do not need to consider your own weight.

船的空間最多能同時容納兩個箱子，而船的最大承重量為 w 公斤。你無需考慮你的重量。

The weights of the boxes are given in a integer list a , which for all $0 \leq i < n$, the weight of box i is $a[i]$ kg. It is known that the weight of any single box does not exceeds w kg.

給定整數串列 a 為箱子的重量，其中對於所有 $0 \leq i < n$ ，箱子 i 的重量為 $a[i]$ 公斤。已知任意單一箱子的重量都不超過 w 公斤。

(a) Complete the function `is_satisfied`, so that `is_satisfied(a, w, x, y)` returns whether box x and box y can be put onto the boat at the same time.

完成函數 `is_satisfied`，使得 `is_satisfied(a, w, x, y)` 返回箱子 x 及箱子 y 能否同時放於船上。

Python

```
def is_satisfied(a: list[int], w: int, x: int, y: int) -> bool:
    return ____ J ____
```

Answer 答案: ____ J ____ (1 mark 分)

(b) Complete the function `find_minimum_rounds`, so that `find_minimum_rounds(a, w)` returns the minimum number of round trips of boats, in order to transfer all the boxes across the river.

完成函數 `find_minimum_rounds`，使得 `find_minimum_rounds(a, w)` 返回船的最少往回次數，以將所有箱子運送過河。

Python

```
def find_minimum_rounds(a: list[int], w: int) -> int:
    n = len(a)
    # sorts a in ascending order 將 a 以遞增次序排序
    a.sort()
    l, r = 0, n - 1
    ans = 0
    while ____ K1 ____:
        if is_satisfied(a, w, l, r):
            ____ K2 ____
            ____ K3 ____
        else:
            ____ K4 ____
        ans += 1
    return ans
```

Answer 答案: ____ K1 ____ ____ K2 ____ ____ K3 ____ ____ K4 ____ (2 marks 分)

END OF PAPER 2 卷二 (Python) 完

Paper 2 卷二 (C++)

	Format 類型	# Questions 題目數	Total Marks 佔分
Section A 甲部	Multiple Choice 多項選擇題	5	5
Section B 乙部	Short Questions 短答題	6 (L - Q)	9
Section C 丙部	Long Questions 長填充題	2 (R - U)	6
Total 總分			20

- (1) Assume that the size of the `int` data type is 32 bits.
假設 `int` 資料類型的長度為 32 位元。
- (2) The following code is added to the beginning of all C++ programs.
在所有 C++ 程序的頂部加入以下程式碼:

C++

```
#include <algorithm>
#include <array>
#include <cmath>
#include <cstdlib>
#include <deque>
#include <forward_list>
#include <iostream>
#include <list>
#include <queue>
#include <stack>
#include <string>
#include <utility>
#include <vector>
using namespace std;
```

- (3) Assume all programs shall be compiled and executed in Debian 12 using the compilers and commands below.

假設所有程序都將在 Debian 12 下使用以下編譯器及指令進行編譯，然後執行。

GNU G++ (g++-12 12.2.0)

```
g++ -std=c++20 program.cpp -o program
```

```
./program
```

Section A 甲部 (5 marks 分)

For each question, choose the **most appropriate** answer and mark the corresponding box (A, B, C, or D) on the answer sheet. One mark for each correct answer. No marks will be deducted for wrong answers.

請為下列每題各選一個**最適合**的答案，然後把答題紙對應的空格（A、B、C、或 D）填滿。
答對得一分，答錯不扣分。

1. Given an integer variable x . Which of the following statements never affects the value of x ?

給定一個整數變量 x 。以下哪個語句必定不會改變 x 的值？

- A. $x += 1;$
- B. $x ^= 2;$
- C. $x \% = 3;$
- D. $x != 4;$

2. Consider the following program: 考慮以下程序：

C++

```
int main() {  
    cout << 2147483647 + 1;  
}
```

We may expect the program to output 2147483648. However, in fact, the program outputs -2147483648.

我們可能期望此程序輸出 2147483648。但是，實際上，此程序輸出了 -2147483648。

This is due to: 這是鑑於：

- A. underflow 下溢出
- B. overflow 上溢出
- C. precision error 精度誤差
- D. truncation error 截斷誤差

3. What is the output of the following program? 以下程序的輸出是什麼？

C++

```
int main() {  
    int s = 0;  
    int x = 1;  
    for (int i = 0; i < 20; ++i) {  
        if (i % 5 == 0) {  
            s += x;  
        }  
        x *= 2;  
    }  
    cout << s;  
}
```

- A. 33825
- B. 1048575
- C. 1082401
- D. 2014751

4. What is the output of the following program? 以下程序的輸出是什麼？

C++

```
int main() {  
    int a[7] = {3, 4, 0, 2, 6, 4, 5};  
    int ans = 0;  
    int x = 0;  
    int y = 1;  
    for (int i = 0; i < 2024; ++i) {  
        ans += a[x] - a[y];  
        x = a[x];  
        y = a[y];  
    }  
    cout << ans;  
}
```

- A. -6735
B. -6742
C. -6744
D. -6745
5. What is the output of the following program? 以下程序的輸出是什麼？

C++

```
void f(int& x, int& y) {  
    x = x + 2;  
    y = y + 3;  
}  
int main() {  
    int a = 20;  
    int b = 30;  
    f(++a, ++b);  
    cout << a << ", " << b;  
}
```

- A. 20, 30
B. 21, 31
C. 22, 33
D. 23, 34

END OF SECTION A 甲部完

Section B 乙部 (9 marks 分)

The blanks are labeled from L to Q. Please fill in the blanks on the answer sheet.

下列各空格分別命名為 L 至 Q，請在答題紙上對應的地方填上答案。

Note 注意：

- (1) Answers must be in C++. Completed programs shall be compiled and executed according to the procedure specified on Page 10.
您必須使用 C++ 作答。完成的程序將以第 10 頁之步驟進行編譯及執行。
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字體須端正清楚，無法辨別之答案當錯誤論。

1. What is the output of the following program? 以下程序的輸出是什麼？

C++

```
int main() {  
    int ans = 0;  
    for (int i = 0; i < 8; ++i)  
        for (int j = 0; j < i - j; ++j)  
            ++ans;  
    cout << ans;  
}
```

Answer 答案: _____ L _____ (1.5 marks 分)

2. What is the output of the following program? 以下程序的輸出是什麼？

C++

```
int main() {  
    int cnt = 0;  
    for (int i = 1; i <= 77; ++i) {  
        if (i % 7 == 0 || i % 10 == 7 || i / 10 == 7) {  
            ++cnt;  
        }  
    }  
    cout << cnt;  
}
```

Answer 答案: _____ M _____ (1.5 marks 分)

3. What is the output of the following program? 以下程序的輸出是什麼？

C++

```
int main() {
    stack<int> a;
    a.push(3);
    while (!a.empty()) {
        int x = a.top();
        a.pop();
        if (x < 0) {
            cout << -x;
        }
        if (x > 0) {
            a.push(x - 1);
            a.push(-x);
            a.push(x - 1);
        }
    }
}
```

Answer 答案: N (1.5 marks 分)

4. In Byteland Secondary School, each school day consists of 7 periods numbered from 0 to 6, inclusive. The arrays `alice` and `bob` store the names of the lessons that Alice and Bob have for each period of the day, respectively. Complete the program such that it outputs the name of the **earliest** (by period number) lesson common to both Alice and Bob. In the case where Alice and Bob share no common periods, the output is empty.
- 在位元組國 (Byteland) 中學，每個上課日由 7 節課組成，從 0 到 6 編號 (含)。陣列 `alice` 和 `bob` 分別存儲愛麗絲和鮑伯在每天各節課的課程名稱。請完成程式，使其輸出愛麗絲和鮑伯**最早** (按課節編號) 共同的課程名稱。如果愛麗絲和鮑伯沒有共同的課程，則輸出為空。

C++

```
string alice[7] = {
    "Chinese", "English", "Math", "Math", "CSD", "PE", "PE"
};
string bob[7] = {
    "Biology", "Biology", "Math", "Math", "Chinese", "PE", "PE"
};
int main() {
    string ans = "";
    for (int i = 0; i < 7; ++i) {
        if (alice[i] == bob[i]) {
            ans = bob[i];
            ____0____;
        }
    }
    cout << ans;
}
```

Answer 答案: O (1.5 marks 分)

5. Assume a is an array of n elements sorted in ascending order with unique elements. Complete the function `NextLargerElement` such that it returns the index of the smallest element in a that is larger than x . If there are no elements larger than x , `NextLargerElement` should return n .

假設 a 是一個有 n 個元素，且按升序排序並元素唯一的陣列。完成函數 `NextLargerElement`，使其返回 a 中大於 x 的最小元素的索引。如果沒有元素大於 x ，`NextLargerElement` 應該返回 n 。

C++

```
int NextLargerElement(vector<int> &a, int x) {  
    int n = a.size();  
    int k = n;  
    for (int i = n - 1; i >= 0; --i) {  
        if (___P___) {  
            k = i;  
        }  
    }  
    return k;  
}
```

Answer 答案: _____ P _____ (1.5 marks 分)

6. Given an array of non-negative integers, its H -index is the largest integer $h \geq 0$, such that at least h of the values in the array are greater than or equal to h . Complete the following function to compute the H -index of the array a .

給定一個由非負整數組成的陣列，其 H -index 為最大整數 $h \geq 0$ ，使得至少 h 個陣列內的元素大於或等於 h 。完成以下函數以計算出陣列 a 的 H -index。

C++

```
int f(vector<int> &a) {  
    int n = a.size();  
    // sorts a in ascending order 將 a 以遞增次序排序  
    sort(a.begin(), a.end());  
    for (int i = n; i > 0; --i) {  
        if (___Q___) {  
            return i;  
        }  
    }  
    return 0;  
}
```

Answer 答案: _____ Q _____ (1.5 marks 分)

END OF SECTION B 乙部完

Section C 丙部 (6 marks 分)

The blanks are labeled from R to U. Please fill in the blanks on the answer sheet.

下列各空格分別命名為 R 至 U，請在答題紙上對應的地方填上答案。

Note 注意：

- (1) Answers must be in C++. Completed programs shall be compiled and executed according to the procedure specified on Page 10.
您必須使用 C++ 作答。完成的程序將以第 10 頁之步驟進行編譯及執行。
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- (3) Answers must not exceed the designated number of boxes.
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字體須端正清楚，無法辨別之答案當錯誤論。
- (5) If blank X is divided into N parts $X_1, X_2, \dots, X_N$, it means that marks will only be given when $X_1, X_2, \dots, X_N$ are all correct.
如果空格 X 分為 N 部份 $X_1, X_2, \dots, X_N$ ，那麼 $X_1, X_2, \dots, X_N$ 皆為正確才會給分。

1. Given an array **a** of **n** unique positive integers.

給定一個包含 **n** 個正整數的陣列 **a**，其中的所有元素都是唯一的。

(a) Complete the function **FindMax** such that it returns the index of the largest element in **a**.

完成函數 **FindMax**，使其返回 **a** 中最大元素的索引。

C++

```
int FindMax(vector<int> &a) {  
    int x = -1;  
    int n = a.size();  
    for (int i = 0; i < n; ++i) {  
        if ( __ R1 __ ) {  
            __ R2 __;  
        }  
    }  
    return x;  
}
```

Answer 答案: R1 R2 (1.5 marks 分)

(b) Complete the function **FindKthSmallest** such that it returns the index of the **k**-th smallest element in **a**. You can make calls to **FindMax** inside your function. Assume **FindMax** is correctly implemented.

完成函數 **FindKthSmallest**，使其返回 **a** 中第 **k** 小元素的索引。你可以在函數內呼叫 **FindMax**。假設 **FindMax** 已被正確地實現。

C++

```
int FindKthSmallest(vector<int> a, int k) {  
    int n = a.size();  
    for (int i = 0; i < n; ++i) {  
        if ( __ S1 __ ) {  
            __ S2 __ = 0;  
        }  
    }  
    return __ S3 __;  
}
```

Answer 答案: S1 S2 S3 (1.5 marks 分)

2. The Byteland Meteorological Agency is upgrading their weather stations to be automated. One of the goals is to calculate the Maximum Sustained Wind over a period of data gathering. A Sustained Wind is the average value of a continuous window of `len` data points.

位元組國 (Byteland) 氣象廳正在升級其氣象站使它們變得自動化。其中一個目的是計算一段數據收集中的最高持續風速 (Maximum Sustained Wind)。持續風速 (Sustained Wind) 是 `len` 個連續的數據點的平均數值。

`data_points` stores the values of `N` data points gathered. It is guaranteed that $1 \leq \text{len} \leq N \leq 10000$ and $1 \leq \text{data_points}[i] \leq 100$.

`data_points` 儲存了 `N` 個收集了的數據點。保證 $1 \leq \text{len} \leq N \leq 10000$ 和 $1 \leq \text{data_points}[i] \leq 100$ 。

(a) Complete the function `MaxSum` such that it returns the maximum sum of values of a continuous window of `len` data points.

完成函數 `MaxSum`，使其返回 `len` 個連續的數據點的最高總和。

C++

```
int MaxSum(vector<int> &data_points, int len) {
    int number_of_points = data_points.size();
    int sum = 0;
    int max_sum = -1;
    for (int i = 0; i < number_of_points; ++i) {
        sum += data_points[i];
        if (i >= _____ T1 _____) {
            max_sum = max(max_sum, sum);
            sum -= data_points[_____ T2 _____];
        }
    }
    return max_sum;
}
```

Answer 答案: _____ T1 _____ T2 _____ (2 marks 分)

(b) Assuming `MaxSum` is correctly implemented, complete the function `MaxSustainedWind` such that it returns the maximum sustained wind in a floating point value. The absolute error of the return value should be less than 0.1.

假設 `MaxSum` 已被正確地實現，完成函數 `MaxSustainedWind`，使其以浮點數返回最高持續風速。返回值的絕對誤差應小於 0.1。

C++

```
double MaxSustainedWind(vector<int> &data_points, int len) {
    return _____ U _____ MaxSum(data_points, len) / len;
}
```

Answer 答案: _____ U _____ (1 mark 分)

END OF PAPER 2 卷二 (C++) 完