C++ Programming

1D Arrays Homework 3

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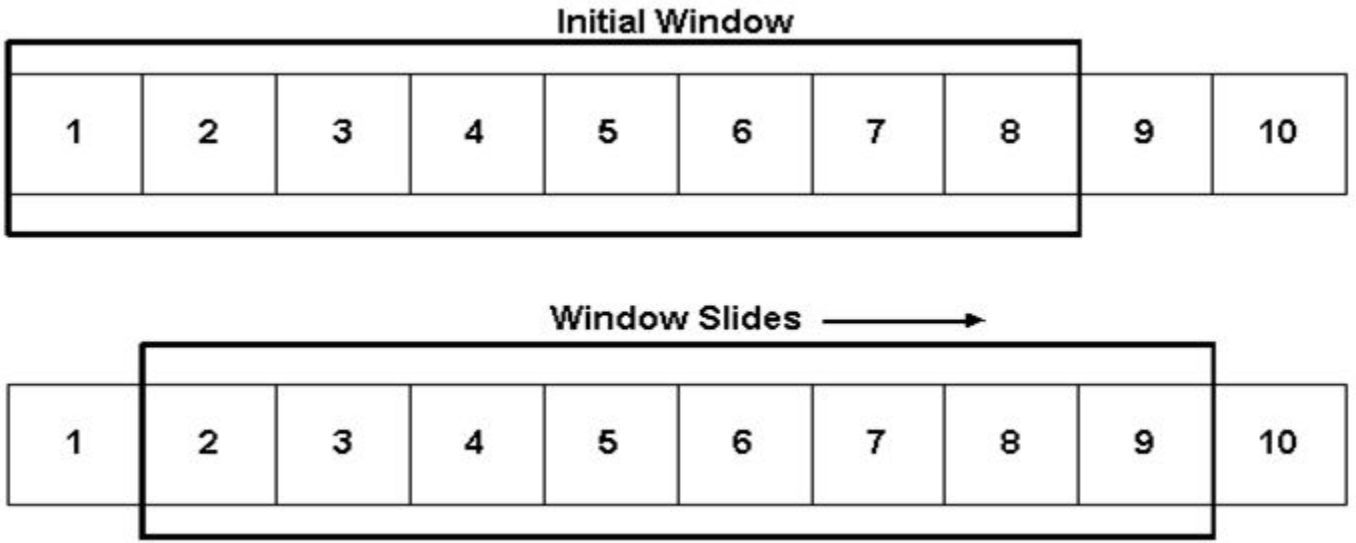
Problem #1: Recamán's sequence

- The first terms of this sequence are 0, 1, 3, 6, 2, **7**, …
  - So last term **value** is 7 and its **index** is 5 (zero based)
  - The next value is either:
    - **LastValue - LastIndex - 1** if the following 2 conditions are satisfied:
      - value > 0 and It did not appear before
      - E.g. 7 (last value) - last index (5) - 1 = 7-5-1 = 1 (> 0 but already exists)
    - Or **LastValue + LastIndex + 1** = 7+5+1 = 13
- Read integer zero-based index ([1, 200]) and print the value of this index
  - E.g. (6 ⇒ 13), (9 ⇒ 21), (17 ⇒ 25)
- Don’t use nested loops
- The series is: 0, 1, 3, 6, 2, 7, **13**, 20, 12, **21**, 11, 22, 10, 23, 9, 24, 8, **25**, 43

Background: Fixed Sliding Window

- Indicate a group of consecutive number. Fixed and variable size
  - You slide to next window



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Background: Fixed Sliding Window

- Assume a list: **1 0 3** -4 2 -6 9
- Sliding window (sublist): 3
- Let’s print all windows of length 3 and their sum
  - 1 0 3 ⇒ sum = 4
  - 0 3 -4 ⇒ sum = -1 [observe 0 3 are common]
  - 3 -4 2 ⇒ sum = 1
  - -4 2 -6 ⇒ sum = -8
  - 2 -6 9 ⇒ sum = 5
- Observe the relation between 2 consecutive windows:
  - They share all the elements except a change in the first / last element
- Variable sliding window: its size grows and shrinks

Problem #2: Fixed sliding window

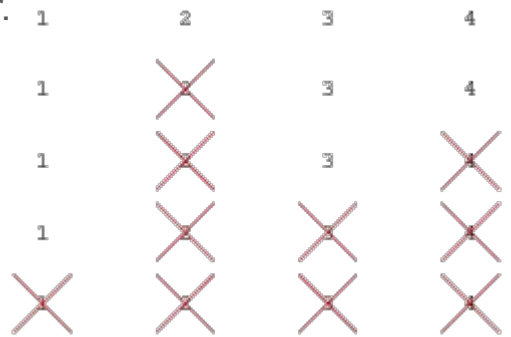
- Read Integers K and N, (where K <= N). then read N < 200 integers.
- Find **sub-array** (consecutive numbers) of K elements that has maximum sum
- Input 3 7 **1 0 3 -4 2 -6 9**
  - Let's list all sub-arrays of length 3
  - 1 0 3 ⇒ sum = 4
  - 0 3 -4 ⇒ sum = -1
  - 3 -4 2 ⇒ sum = 1
  - -4 2 -6 ⇒ sum = -8
  - 2 -6 9 ⇒ sum = 5
- Output: 4 6 5 (Sub-array from indices 4 to 6 has maximum sum of 5)
- Can you do it without nested loops? There are 2 ways.

Problem #3: Count increasing subarrays

- Read an Integer N, then read N (< 200) integers.
- Output: **Count** how many **subarrays** are **increasing** in the array.
- E.g. If input is 1 2 3 4
  - We can find all sublists of length 1 ⇒ [1], [2], [3], [4]
  - All sublists of length 2 ⇒ [1, 2], [2, 3], [3, 4]
  - All sublists of length 3 ⇒ [1, 2, 3], [2, 3, 4]
  - All sublists of length 4 ⇒ [1, 2, 3, 4]
- Inputs ⇒ Outputs
  - 4 **1 2 3 4** ⇒ 10 [10 sub-arrays from previous example, all are increasing]
  - 4 **4 3 2 1** ⇒ 4 [only sub-arrays of length 1 can be considered]
  - 4 **10 20 1 5** ⇒ 6
- Easy using 3 nested loops. Medium using 2 loops. Hard with 1 loop

Problem #4: Josephus problem

- Read integers N (< 200) and K (<= 1000000). *Code for small K first*
  - Find the game winner for following game:
- There is a group of N people in Circle numbered 1, 2, …. N
  - Someone is a master of the game.
  - He starts from Person #1. Count K. Then remove this person from the circle.
  - He keeps doing so till only 1 person remains. This is the winner.
- Input 4 2
  - Means we have people: 1, 2, 3, 4. Master starts at 1
  - Count 2 persons (2 removed), start from 3
  - Count 2 persons (4 removed), start from 1
  - Count 2 persons (3 removed), 1 is winner
- Output
  - People removed in order: 2 4 3 1 [same answer for 10 2 why?]



Problem #4: Josephus problem

- Input ⇒ Output
  - 7 1 ⇒ 1 2 3 4 5 6 7
  - 7 2 ⇒ 2 4 6 1 5 3 7
  - 7 3 ⇒ 3 6 2 7 5 1 4
  - 7 4 ⇒ 4 1 6 5 7 3 2
  - 7 5 ⇒ 5 3 2 4 7 1 6
  - 7 6 ⇒ 6 5 7 2 1 4 3
  - 7 7 ⇒ 7 1 3 6 2 4 5
  - 7 14 ⇒ 7 2 6 3 5 4 1
  - 7 1000 ⇒ 6 3 2 1 4 7 5
  - 7 99999 ⇒ 4 7 5 2 1 3 6

Problem #5: longest subarray

- Read integer N (< 1000) then N read numbers each is either 0 or 1.
- Find the longest **subarray** with number of zeros = numbers of ones
  - You can easily implement it using 3 loops
  - Or with little thinking using 2 loops (even with no extra arrays)
  - Hard: You can implement it without any nested loops
- Inputs ⇒ outputs
  - 7 1 0 0 0 1 1 1 ⇒ 6 (e.g. 100011 or 000111)
  - 19 1 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 0 0 1 ⇒ 8 (e.g. 00101101)
- Reduction
  - How may this problem be reduced to another problem: longest subarray of zero sum?

"Acquire knowledge and impart it to the people."

"Seek knowledge from the Cradle to the Grave."