Worksheet: Nested Iteration

CS 101 Algorithmic Problem Solving

Fall 2023

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1. Good Boy

You adopted a dog not too long ago that has a knack for solving mathematical problems. You write things on a white board and the dog responds by pressing keys on a large keypad you built for him.

Recently, you've discovered that he's quite good at performing the $sum(N)$ function, i.e. summing all natural numbers up until the specified number N. He's gotten so good in fact, that he can easily perform this function multiple times in one go, giving you the answer faster than it would take you to type in a calculator.

Your dog has expertly defined this repeated sum function as $sum(D, N)$, which denotes the $sum(N)$ function applied D times repeatedly: the first time it sums up till N, and each subsequent time to the result of the previous sum function. For example, $sum(2, 3)$ is equivalent to $sum(sum(3)) = sum(1 + 2 + 3) = sum(6) = 21$.

You have found this repeated sum function to be quite useful, and want to try your own hand at it for times when your dog is not there to help you out.

Given values of D and N, determine the output of the $sum(D, N)$ function.

Constraints

- $D, N \in \mathbb{N}$
- $1 \leq D, N \leq 10^5$

Interaction

The input comprises of a single line containing 2 space-separated integers denoting the values of D and N respectively.

The output must be a single integer denoting the value of $sum(D, N)$.

Sample

Input	Output
5 2	26796
1 10	55

In the first case, $(D, N) = (5, 2)$. $sum(5, 2)$ is equivalent to $sum(sum(sum(sum(sum(2))))) = 26796$.

In the second case, $(D, N) = (1, 10)$. $sum(1, 10)$ is equivalent to $sum(10) = 55$.

Exercise

In the space provided, indicate the outputs for the given inputs.

Input	Output
2 6	231
112 1	1
3 2	21

Problem Identification

Briefly explain the underlying problem you identified in the above question that led you to your solution.

Input: D N
Output: $sum^D(N)$

Pseudocode

```
for i in range(D):
    num = 0
    for j in range(1, N+1):
        num += j
    N = num
return num
```

Dry Run

Below, dry run your pseudocode on any two of the inputs provided in the Exercise section.

D	N	i	j	num
3	2			
		0		0
			1	1
			2	3
	3			
		1		0
			1	1
			2	3
			3	6
	6			
		2		0
			1	1
			2	3
			3	6
			4	10
			5	15
			6	**21**
	21			
		return 21		

D	N	i	j	num
112	1			
		0		0
			1	1
	1			
		1		0
			1	1
	1			
		2		0
			1	1
	1			
		3		0
			1	1
	1			
		4		0
			1	1
	1			
		...		
		111		0
			1	**1**
	1			
		return 1		

2. Baby's First Question

You've just solved your first question on HackerRank. The question you solved has N test cases. You will receive a score according to the following conditions:

- If the solution passes all N test cases, you get 100 points.
- If it does not pass all test cases but passes the first M ($M < N$) test cases, you get K ($K < 100$) points.
- If neither of the above conditions are satisfied, you receive 0 points.

You are given a sequence of integers $(A_1 A_2 \dots A_N)$ as a string S, where $A_i = 1$ if you passed the ith test case and $A_i = 0$ otherwise. In addition, you are also given the values of M and K. Determine how many points you will receive.

Constraints

- $N, M, K, A_1, A_2, \dots, A_N \in \mathbb{Z}$
- $1 \leq M < N \leq 10$
- $1 \leq K < 100$
- $A_i \in \{0, 1\}$

Interaction

The first line of the input contains 3 space-separated integers denoting the values of N, M, and K respectively. The second line of the input contains *string* S which is an N-long sequence of integers in the form $A_1 A_2 \dots A_N$.

The output must be a single integer denoting how many points you received.

Sample

Input	Output
4 2 50 "1011"	0
3 2 66 "110"	66

In the first case, $(N, M, K) = (4, 2, 50)$ and S = 1011. Your solution does not pass all 4 test cases, nor does it pass the first 2 test cases, failing at test case 2. You receive 0 points.

In the second case, $(N, M, K) = (3, 2, 66)$ and S = 110. Your solution does not pass all 3 test cases, but it does pass the first 2 test cases. Hence, you receive 66 points.

Exercise

In the space provided, indicate the outputs for the given inputs.

Input	Output
4 2 50 "1111"	100
5 3 30 "11011"	0
10 7 60 "1111101111"	0

Problem Identification

Briefly explain the underlying problem you identified in the above question that led you to your solution.

Input: N, M, K, S
Output: 100 if S contains all 1s else K if the first M characters in S are 1 else 0

Pseudocode

```
count = 0
for c in S:
    if c == '1':
        count += 1
    else:
        break
if count == N:
    return 100
elif count >= M:
    return K
else:
    return 0
```

Dry Run

Below, dry run your pseudocode on any two of the inputs provided in the Exercise section.

N	M	K	S	c	count
4	2	50	'1111'		0
				'1'	1
				'1'	2
				'1'	3
				'1'	4
return 100					

N	M	K	S	c	count
5	3	30	'11011'		0
				'1'	1
				'1'	2
				'0'	
return 0					

3. Lucky Days

You and a group of friends have been obsessed with the idea of "lucky days". A lucky day is one where, if the date is represented in the format DD/YY/MM, the date is palindromic OR if changing any ONE digit in the date's representation makes it palindromic. Your friends have compiled a dataset of of 6 digit long integers representing dates from the 20th century, such that the first 2 digits represent the day, the middle 2 represent the year, and the last two represent the month. For example, 30th March 2022 would be represented as 302203. Given an integer N, determine if it represents a lucky day.

Constraints

- $N \in \mathbb{N}$
- N contains 6 digits. The first digit can be 0.
- The first 2 digits of N are between 01 and 31, the middle 2 digits are between 00 and 99, and the last 2 digits are between 01 and 12.

Interaction

The input comprises of a single line containing a single 6 digit long integer denoting the value of N.

The output must be "YES" if the integer represents a lucky day, and "NO" otherwise.

Sample

Input	Output
213212	"YES"
218812	"YES"

In the first case, $N = 213212$. Changing the 4th digit in N to a 3 makes it 213312 which is palindromic and hence, it is a lucky day.

In the second case, $N = 218812$. As N backwards is $218812 = N$, it is a lucky day.

Exercise

In the space provided, indicate the outputs for the given inputs.

Input	Output
204412	"YES"
121212	"NO"
101011	"NO"

Problem Identification

Briefly explain the underlying problem you identified in the above question that led you to your solution.

Input: N
Output: "YES" if N is palindromic with changes in 0 or 1 of its digits, "NO" otherwise.

Pseudocode

```
count = 0
for i in range(1,4):
    rem = N % (10 ** i)
    right = remainder // (10 ** (i-1))
    quotient = N // (10 ** (6-i))
    left = quotient % 10
    if left != right:
        count += 1
if count <= 1:
    return 'YES'
else:
    return 'NO'
```

Dry Run

Below, dry run your pseudocode on any two of the inputs provided in the Exercise section.

N	i	rem	right	quotient	left	count
204412						0
	1	2	2	2	2	
	2	12	1	20	0	1
	3	412	4	204	4	
return "YES"						
121212						0
	1	2	2	1	1	1
	2	12	1	12	2	2
	3	212	2	121	1	3
return "NO"						

4. Staircase

Ahmed loves playing with numbers to create beautiful patterns. Given the number N, help him come up with a following pattern that is a staircase of N stairs with each stair having unique odd numbers as shown in the sample below.

Constraints

- $N \in \mathbb{Z}$
- $1 \leq N \leq 10$

Interaction

The input comprises a single line containing a single integer denoting the value of N.

The output must consist of N lines containing the pattern as described above (and shown below).

Sample

Input	Output
2	1 3 5
3	1 3 5 7 9 11

In the first case, $N = 2$. The pattern consists of 2 lines, each line containing as many positive odd integers as the respective line number.

In the second case, $N = 3$. The pattern consists of 3 lines, each line containing as many positive odd integers as the respective line number.

Exercise

In the space provided, indicate the outputs for the given inputs.

Input	Output
4	1 3 5 7 9 11 13 15 17
5	1 3 5 7 9 11 13 15 17 19 21 23 24

Problem Identification

Briefly explain the underlying problem you identified in the above question that led you to your solution.

Input: N
Output: N printed lines where line 1 contains 1 and line i contains the i odd numbers following the last number on line $(i - 1)$.

Pseudocode

```python
odd = 1
for i in range(N):
    for j in range(i+1):
        print(odd, end = ' ')
        odd += 2
    print()
```

Dry Run

Below, dry run your pseudocode on any two of the inputs provided in the Exercise section.

N	i	j	odd	output
4			1	
	0	0	3	1
	1	0	5	1 3
	1	1	7	1 3 5
	2	0	9	1 3 5 7
	2	1	11	1 3 5 7 9
	2	2	13	1 3 5 7 9 11
	3	0	15	1 3 5 7 9 11 13
	3	1	17	1 3 5 7 9 11 13 15
	3	2	19	1 3 5 7 9 11 13 15 17
	3	3	21	1 3 5 7 9 11 13 15 17 19

N	i	j	odd	output
5			1	
i = 0 to i = 3 as in the previous table				
	4	0	23	1 3 5 7 9 11 13 15 17 19 21
	4	1	25	1 3 5 7 9 11 13 15 17 19 21 23
	4	2	27	1 3 5 7 9 11 13 15 17 19 21 23 25
	4	3	29	1 3 5 7 9 11 13 15 17 19 21 23 25 27
	4	4	31	1 3 5 7 9 11 13 15 17 19 21 23 25 27 29

5. Family Legacy

In the futuristic city of Byteville, where holographic screens and AI-powered companions are the norm, a young coder named Ava stumbles upon an old data drive in her family's attic. This seemingly ancient artifact contained a cryptic Python script for creating a stunning

numerical pattern. Intrigued by its simplicity and elegance, Ava set out to decipher the script and uncover the secrets behind the mesmerizing pattern.

Ava, fueled by her passion for programming, meticulously studied the script, noticing the clever use of nested loops. As she executed the code, it prompted for an integer input and Ava complied; she entered a number N and the holographic display came alive, showcasing a cascade of numbers where each row displayed a series of numbers in ascending order with each subsequent row containing less numbers. Ava showed you the pattern generated, but refused to show you its code as she believes it to be a part of her family's legacy.

You wish to recreate this program. Given an integer N, create a program that prints the pattern described above (and shown below).

Constraints

- $N \in \mathbb{Z}$
- $1 \leq N \leq 10$

Interaction

The input comprises a single line containing a single integer denoting the value of N.

The output must consist of N lines containing the pattern as described above (and shown below).

Sample

Input	Output
2	1 2 1
3	1 2 3 1 2 1

In the first case, $N = 2$. The pattern consists of 2 lines. Each line contains integers in ascending order (starting from 1) separated by a space.

In the second case, $N = 3$. The pattern consists of 3 lines. Each line contains integers in ascending order (starting from 1) separated by a space.

Exercise

In the space provided, indicate the outputs for the given inputs.

Input	Output
4	1 2 3 4 1 2 3 1 2 1
5	1 2 3 4 5 1 2 3 4 1 2 3 1 2 1

Problem Identification

Briefly explain the underlying problem you identified in the above question that led you to your solution.

Input: N
Output: N printed lines where line N contains 1 and line i contains the numbers from 1 to $(N - i + 1)$.

Pseudocode

```
for i in range(N, 0, -1):
    for j in range(1, i+1):
        print(j, end = ' ')
    print()
```

Dry Run

Below, dry run your pseudocode on any two of the inputs provided in the Exercise section.

N	i	j	output
4	4	1	1
		2	1 2
		3	1 2 3
		4	1 2 3 4
	3	1	1 2 3 4 1
		2	1 2 3 4 1 2
		3	1 2 3 4 1 2 3
	2	1	1 2 3 4 1 2 3 1
		2	1 2 3 4 1 2 3 1 2
	1	1	1 2 3 4 1 2 3 1 2 1

N	i	j	output
5	5	1	1
		2	1 2
		3	1 2 3
		4	1 2 3 4
		5	1 2 3 4 5
	4	1	1 2 3 4 5 1
		2	1 2 3 4 5 1 2
		3	1 2 3 4 5 1 2 3
		4	1 2 3 4 5 1 2 3 4
	3	1	1 2 3 4 5 1 2 3 4 1
		2	1 2 3 4 5 1 2 3 4 1 2
		3	1 2 3 4 5 1 2 3 4 1 2 3
	2	1	1 2 3 4 5 1 2 3 4 1 2 3 1
		2	1 2 3 4 5 1 2 3 4 1 2 3 1 2
	1	1	1 2 3 4 5 1 2 3 4 1 2 3 1 2 1

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6. Unique Numbers

You are given two baskets, X_1 and X_2. X_1 contains all integers in the range $[A, B]$ and X_2 contains all integers in the range $[C, D]$. You want to combine these two baskets into a third basket such that there are no duplicate elements.
Given the values of A, B, C, and D, determine the size of the third basket.

Constraints

- $A, B, C, D \in \mathbb{N}$
- $1 \leq A \leq B \leq 20$
- $1 \leq C \leq D \leq 20$

Interaction

The input comprises a single line containing 4 space-separated integers denoting the values of A, B, C, and D respectively.

The output must contain a single number denoting the size of the third basket.

Sample

Input	Output
5 9 7 11	7
5 9 11 15	10

In the first case, $(A, B, C, D) = (5, 9, 7, 11)$. There are 5 integers in X_1 and 5 integers in X_2, but there's 3 integers i.e. $7, 8, 9$ which are in both X_1 and X_2, so the size of the third basket is 7.

In the second case, $(A, B, C, D) = (5, 9, 11, 15)$. There are 5 integers in X_1 and 5 integers in X_2, and no such integers which are in both X_1 and X_2, so the size of the third basket is 10.

Proposed Solution

```
count = (B-A) + 1 # counting all the numbers in [A,B]
for i in range(C, D):
  if i > B or i < A:
    count += 1
print(count)
```

Dry Run

Below, dry run the proposed pseudocode on the inputs provided in the Sample section.

A	B	C	D	i	count
5	9	7	11		5
				7	
				8	
				9	
				10	**6**
return 6					

A	B	C	D	i	count
5	9	11	15		5
				11	6
				12	7
				13	8
				14	**9**
return 9					

Error Identification

Briefly explain the errors you identified in the proposed code solution. Mention the line number and the errors in each line.

Line 2: `range(C, D)` should be `range(C, D+1)`.