Worksheet: Nested Iteration

CS 101 Algorithmic Problem Solving

Fall 2023

Name(s): _____

HU ID *(e.g., xy01042)*: _____

1. The Prime Village Challenge

In the picturesque village of "PakMath," nestled at the foot of the magnificent Himalayas, there lived a brilliant mathematician named Aleena. Aleena was not only known for her deep love of mathematics but also for her devotion to her village. She ran a quaint printing shop called "Prime Prints," where she often displayed prime number posters, inspiring young minds in PakMath.

One sunny day, a group of aspiring mathematicians from PakMath: Saba, Hasan, and Ayesha, visited Aleena's shop. Impressed by the prime number posters, Aleena decided to challenge them to create a program that could print all prime numbers within a specified range, from A to B (both inclusive). The reward for their success? Their names would be featured on a grand banner adorned with prime numbers, a token of recognition for their contribution to PakMath's mathematical legacy.

The group of young mathematicians eagerly accepted the challenge, and together, they embarked on a coding adventure that would leave a lasting mark on PakMath.

If you were one of the young mathematicians in the story given two integers A and B, how would you implement a program to print all prime numbers within the range?

Constraints

- $A, B \in \mathbb{Z}$
- $0 \leq A, B \leq 10^5$
- $A \leq B$

Interaction

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

The output must be a single line, containing all prime numbers in the given range separated by a space.

Sample

Input	Output
1 10	2 3 5 7
3 5	3 5

In the first case, $(A, B) = (1, 10)$. The primes in the range are 2, 3, 5, and 7. Note that 1 is not a prime number.

In the second case, $(A, B) = (3, 5)$. The primes in the range are 3 and 5.

Exercise

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

Input	Output
0 20	2 3 5 7 11 13 17 19
1 2	2
21 30	23 29

Problem Identification

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

Input: A, B
Output: all prime numbers in range (A, B) inclusive

Pseudocode

```
A,B = int(input())
is_prime = False

if A < 2: # to ensure our range begins with 2
    A = 2

for number in range(A, B+1):
    is_prime = True
    for divisor in range(2, int(number**0.5)+1):
        if number % divisor == 0:
            is_prime = False
            break
    if is_prime:
        return number
```

Dry Run

Using any two of the inputs provided in the Exercise section above, dry run your pseudocode in the space below.

Input: (A,B) = (1,2)
Output:

$A < 2$ so $A = 2$

	number	is_prime	divisor	output
1st Iter	2	True	2	2

Loop breaks and only 2 is printed on screen which is the expected output.

Input: (A,B) = (21,30)
Output:

$A > 2$ so $A = 21$

	number	is_prime	divisor	output
1st Iter	21	True,False and loop breaks	2,3	
2nd Iter	22	False and loop breaks	2	
3rd Iter	23	True,True,True,True	2,3,4,5	23
4th Iter	24	False and loop breaks	2	23
5th Iter	25	True,True,True,False and loop breaks	2,3,4,5	23
6th Iter	26	False and loop breaks	2	23
7th Iter	27	True, False and loop breaks	2,3	23
8th Iter	29	True,True,True,True	2,3,4,5	23 29

which is the expected output!

This means the applied logic is correct

2. The Discovery of Dr. Khan

In the heart of Lahore, at the prestigious Lahore Institute of Science and Technology (LIST), there was a brilliant yet unconventional scientist named Dr. Ahmed Khan. Dr. Khan was renowned for his pioneering research in the field of molecular cryptography. One fateful day, while exploring the institute's archives, he stumbled upon a vial containing a three-letter string, "XYZ," which had remained a mystery for decades.

Driven by his insatiable scientific curiosity, Dr. Khan believed that deciphering this enigmatic code could unlock a groundbreaking scientific formula. He saw it as a challenge worthy of his intellect and a chance to make a significant contribution to Pakistani science.

To unravel the secrets hidden within "XYZ," Dr. Khan embarked on a daring experiment. His goal was to find all possible permutations of these three letters, hoping that one of these permutations might reveal the long-lost formula.

Suppose you are in Dr. Khan's position. Write a program to find all possible permutations of a given three-letter string S.

Note: You must use iteration to accomplish this.

Constraints

- $len(S) = 3$
- All three letters of the string are unique.

Interaction

The input comprises a single 3-letter string S.

The output must be a single line containing all permutations of the three letters separated by a space.

Sample

Input	Output
"ABC"	ABC ACB BAC BCA CAB CBA
"XYA"	XYA XAY YXA YAX AXY AYX

In the first case, S = "ABC". The 6 possible permutations are ABC, ACB, BAC, BCA, CAB, and CBA.

In the second case, S = "XYA". The 6 possible permutations are XYA, XAY, YXA, YAX, AXY, and AYX .

Exercise

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

Input	Output
"NOM"	NOM NMO ONM OMN MNO MON
"APS"	APS ASP PAS PSA SAP SPA
"HUM"	HUM UHM MUH MHU UMH HMU

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

Input: S
Output: all unique permutations of the three letter string

Pseudocode

```
word = input()

for a in word:
    for b in word:
        if b != a:
            for c in word:
                if c != a and c != b:
                    permutation = a + b + c
                    return permutation
```

Dry Run
Using any two of the inputs provided in the Exercise section above, dry run your pseudocode in the space below.

word = "NOM"

	a	b	b!=a	c	c!=a	c!=b	permutations	output
1st	N	N	False					
2nd	N	O	True	N	False	True		
3rd	N	O	True	O	True	False		
4th	N	O	True	M	True	True	NOM	NOM
5th	N	M	True	N	False	True		
6th	N	M	True	O	True	True	NMO	NOM NMO
7th	N	M	True	O	True	False		
8th	O	N	True	N	True	False		
9th	O	N	True	O	False	True		
10th	O	N	True	M	True	True	ONM	NOM NMO ONM
11th	O	O	False					
12th	O	M	True	N	True	True	OMN	NOM NMO ONM OMN
13th	O	M	True	O	False	True		
14th	O	M	True	M	True	False		
15th	M	N	True	N	True	False		
16th	M	N	True	O	True	True	MNO	NOM NMO ONM OMN MNO
17th	M	N	True	M	False	True		
18th	M	O	True	N	True	True	MON	NOM NMO ONM OMN MNO MON
19th	M	O	True	O	True	False		
20th	M	O	True	M	False	True		
21st	M	M	False					

which is the expected output!

This means the applied logic is correct

3. The Symmetrical Spectacle in Karachi

In the vibrant city of Karachi, known for its rich cultural diversity and annual festivities, there was an extraordinary event called the "Symmetrical Carnival." This event celebrated the beauty of symmetry in all its forms. The highlight of the carnival was the "Palindromic Parade," where participants showcased their love for symmetrical patterns.

This year, the carnival organizers issued a special challenge to the residents: create a program that generates N rows of palindromic numbers. Inspired by the theme of symmetry, the challenge required these rows to read the same forwards and backward, echoing the spirit of the parade.

Among the talented participants was a young computer enthusiast named Zainab. Zainab eagerly accepted the challenge, determined to craft a program that would capture the essence of symmetry and bring it to life on the parade route.

With dedication and creativity, Zainab developed a Python program that utilized nested iterations. Her program meticulously constructed each row by adding numbers from 1 to N in ascending and descending order, resulting in beautiful palindromic sequences. As the program ran, it replicated the symmetry of the carnival's theme, earning Zainab the admiration and applause of the entire city.

You want to figure out Zainab's program for yourself. Given an integer N, write a program that replicates the output of Zainab's program.

Constraints

- $N \in \mathbb{Z}$

- $0 \leq N \leq 10^5$

Interaction

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

The output must consist N lines, each containing a palindromic number.

Sample

Input	Output
3	1
	121
	12321
2	1
	121

In the first case, $N = 3$. The output consists of 3 palindromic numbers printed on 3 separate lines.

In the second case, $N = 2$. The output consists of 2 palindromic numbers printed on 2 separate lines.

Exercise

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

Input	Output
4	1
	121
	12321
	1234321
5	1
	121
	12321
	1234321
	123454321

Problem Identification

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

Input: N
Output: N rows each row containing numbers from 1 to R back to 1 with R corresponding to current row number

Pseudocode

Input: N

```
    for i in range(1, N+1):
    # Print numbers in ascending order
        for j in range(1, i+1):
            print(j, end="")

        # Print numbers in descending order
        for j in range(i - 1, 0, -1):
            print(j, end="")

        print()  # Move to the next line for the next row
```

Dry Run

Using any two of the inputs provided in the Exercise section above, dry run your pseudocode in the space below.

$N = 4$

	i	**j**	**output**	
i in range(1,5)	1	1	1	no descending numbers
	2	1,2	12	
descending	2	1	121	
	3	1,2,3	123	
descending	3	2,1	12321	next line
	4	1,2,3,4	1234	
descending	4	3,2,1	1234321	

final output:
1
121
12321
1234321
which is the expected output!

This means the applied logic is correct

Rough Work