Name: Roll Number:

ESO207: Data Structures and Algorithms

Programming Assignment 1

Due Date: 27th August 11:59pm, 2025

Total Number of Pages: 4 Total Points 100

Note :

- The questions have to be answered through a contest in Hackerrank. The contest has 3 challenges, each corresponding to a question. You have to submit your code through the contest.
- Contest Link: `https://www.hackerrank.com/programming-assignment-1-1755246060`
- Additionally you must upload your solutions on hello.iitk.ac.in as well. You need to upload 3 files corresponding to the 3 programs.
- Your codes will be checked for possible plagiarism of any sorts. If we find such cases, then we will possibly award an F grade.
- Allowed Languages for challenge code submission : C, C++
- Allowed libraries : stdio.h for C and iostream for C++

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Question 1. (30 points) **Problem 1 - Counting-GCDs**

You are given an array a of length n consisting of integers $a_1, a_2, \ldots, a_n$.

We say that an array is k-nice if the greatest common divisor (gcd) of all its elements is exactly k.

You are given an integer m. Your task is to determine the number of contiguous subarrays of a that are m-nice.

- **Input**

  The first line contains one integer t — the number of test cases.

  Each test case contains two lines. The first line contains two integers n and m — the length of the array and the parameter m. The second line contains n integers $a_1, a_2, \ldots, a_n$ — the elements of the array.

- **Output**

  For each test case, print one integer — the number of contiguous subarrays of a that are m-nice.

- **Constraints**
  - $1 \leq t \leq 10^6$
  - $1 \leq n \leq 6 \times 10^5$
  - $1 \leq m \leq 10^9$
  - $1 \leq a_i \leq 10^9$
  - The total sum of n over all test cases does not exceed 3×10^6

- **Sample Input**

```
2
6 3
3 6 9 12 15 18
4 5
5 10 15 25
```

- **Sample Output**

```
16
7
```

- **Explanation**

  Test case 1: We need subarrays whose gcd is exactly 3. Valid subarrays are [3], [3, 6], [6, 9], [9, 12], [12, 15], [15, 18], [3, 6, 9], [6, 9, 12], [9, 12, 15], [12, 15, 18], [3, 6, 9, 12], [6, 9, 12, 15], [9, 12, 15, 18], [3, 6, 9, 12, 15], [6, 9, 12, 15, 18], [3, 6, 9, 12, 15, 18]. Total count = 16.

  Test case 2: We need subarrays whose gcd is exactly 5. Valid subarrays are [5], [5, 10], [5, 10, 15], [10, 15, 25], [15], [15, 25], [25]. Total count = 7.

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Question 2. (20 points) **Problem 2 - Rectangle of Riches**

You discovered an ancient treasure map represented as an $n \times m$ grid.
Each cell contains an integer:

- A positive number represents gold coins buried in that spot.
- A negative number represents traps that will cost you resources (equal to the number of gold coins lost).

You can choose any rectangular area of the map to dig.
Your task is to maximize the gold coins collected by choosing a profitable rectangle.

- **Input**
  The first line contains two integers n and m — the number of rows and columns.
  The next n lines each contain m integers, representing the grid.
- **Output**
  Line 1: `YES` if it is profitable to dig, or `NO` if it is not profitable.
  Line 2: If `YES`, print the maximum number of gold coins you can collect.
  Line 3: If `YES`, Print the four corners of the rectangle r_1, c_1, r_2, c_2.
- **Constraints**
  $1 \leq n, m \leq 300$
  $-1000 \leq grid[i][j] \leq 1000$
- **Sample Input**

```
4 5
1 2 -1 -4 -20
-8 -3 4 2 1
3 8 10 1 3
-4 -1 1 7 -6
```

- **Sample Output**

```
YES
29
2 2 4 4
```

- **Explanation 0**
  We can find a rectangle such that it is profitable to dig. The rectangle with top-left corner $(2, 2)$ and bottom-right corner $(4, 4)$ contains the maximum sum.
  $(-3 + 4 + 2) + (8 + 10 + 1) + (-1 + 1 + 7) = 3 + 19 + 7 = 29$

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Question 3. (50 points) **Problem 3 - Pandemic**

A special kind of bacteria produces i children on its i^{th} day after birth. Each bacteria dies after k days from birth (dies after producing its k children). There are n freshly born bacteria on day 0. Output the total population of bacteria after d days. Since the answer can be very large, output it modulo $10^9 + 7$.

- **Input**
  The first line contains three integers n, k, and d.
- **Output**
  Print a single integer — the total population of bacteria after d days, modulo $10^9 + 7$.
- **Constraints**
  $1 \leq n \leq 10^6$
  $1 \leq k \leq 40$
  $1 \leq d \leq 10^9$
- **Sample Input**

```
1 2 3
```

- **Sample Output**

```
8
```

- **Explanation 0**
  Day 0: Start with 1 bacteria. Population = 1.
  Day 1: The original produces 1 child. Total population = 1 (original) + 1 (new) = 2.
  Day 2:
  Original produces 2 children and dies.
  The Day 1 child produces 1 child. Total population = 2 (from original) + 1 (from Day 1 child) + 1 (Day 1 child still alive) = 4.
  Day 3:
  The Day 1 child produces 2 children and dies.
  The 3 bacteria from Day 2 each produce 1 child. Total population = 2 (from Day 1 child) + 3 (from Day 2 bacteria) + 3 (Day 2 bacteria still alive) = 8.