UNSW CPMSoc
O-Week Contest 2022
Task Statements

CPMSOC

Some Sum

Maths, Beginner-Friendly

Hello there!

Your first task is to evaluate $1 + 10 + 100 + 1000 + 1000 - 100 + 10 + 1$.

Enter your answer into the box below to submit and check your answer!

For all the tasks, including this one, you can submit as many times as you like with no penalty! Only your best submission will be counted.

Turning Point (Part 1)

Maths, Beginner-Friendly

Find a non-constant polynomial in x which:

- Has real integer coefficients, and
- Has a stationary point at $x = 3$.

Submit your answer as a comma-separated list whose length is one more than the degree of your polynomial, which contains the polynomial's coefficients, in order from highest to lowest powers of x.

For example, if your polynomial is $2x^4 - 3x^2 + x - 7$, you should submit "2, 0, -3, 1, -7".

Turning Point (Part 2)

Maths, Beginner-Friendly

Find a non-constant polynomial in x which:

- Has real integer coefficients, and
- Has a stationary point at $x = \sqrt{3}$.

Submit your answer as a comma-separated list whose length is one more than the degree of your polynomial, which contains the polynomial's coefficients, in order from highest to lowest powers of x.

For example, if your polynomial is $2x^4 - 3x^2 + x - 7$, you should submit "2, 0, -3, 1, -7".

Sandwich

Programming, Beginner-Friendly

Program time limit: 1 second
Program memory limit: 256 MB

Michael is on the verge of becoming the best chef in all of Melbourne, but there's one last dish that he needs to master... the perfect sandwich.

To achieve this goal, Michael starts with a rectangular slice bread measuring W cm by H cm. From this slice, he must cut out two identical squares to form the top and bottom of his sandwich. Also, since this is the perfect sandwich, Michael also requires that both squares must have an integer side length. **You may assume that Michael only makes cuts in the bread parallel to the edges of the slice.**

Of course, Michael knows that the perfect sandwich must also minimise food wastage. Write a program to help Michael find the minimum area of unused bread that he can leave behind after creating the perfect sandwich.

Input

The first and only line of input contains 2 space-separated integers W and H, which are the width and height of the initial bread slice, respectively.

You should read from standard input. In C or C++, you could use the line `int W, H; scanf("%d%d", &W, &H);`. In Python, you could use the line `W, H = map(int, input().split())`.

Constraints

Each input case will satisfy the following constraints:

- $1 \leq W, H \leq 100$
- The area of the initial bread slice is at least 2.

Output

Output a single integer, representing the minimum area of unused bread after creating the perfect sandwich.

You should write to standard output. In C or C++, you could use the line `printf("%d", answer);`. In Python, you could use the line `print(answer)`.

Sample Input 1

```
5 7
```

Sample Output 1

```
17
```

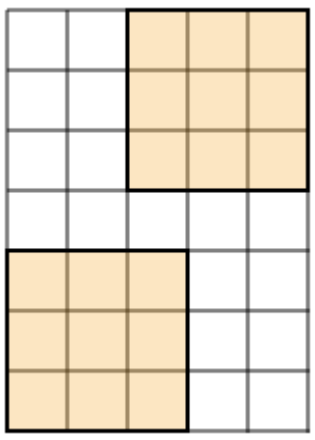
Sample Input 2

```
8 4
```

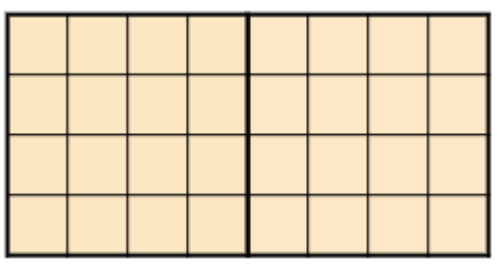
Sample Output 2

```
0
```

Explanation



In sample case 1, Michael can cut out two 3 by 3 slices for a total used area of 18, leaving behind 17 units of unused bread.



In sample case 2, Michael can cut right down the middle to form two perfect 4 by 4 square slices. This leaves no wasted bread, and so the answer is 0.

Scoring

Your program will be tested on the 2 samples and 8 secret input cases one after another. Your score for the submission will be proportional to the amount of test cases for which you output the correct answer.

Tennis (Part 1)

Maths

You and your friend are playing a set of tennis. The winner of the set is the first to win 6 games.

Each game is played by standard tennis rules, which will be restated now. A game consists of a series of points, each of which either you or your friend wins. The game ends, and is won by the player who has won more points in the game, when both of the following are true:

- At least one player has won at least 4 points, and
- The difference between the points won by each player is at least 2.

You enjoy teasing your friend, and to do so, you should win the set, but win the lowest proportion of points (across all games) possible. What is the lowest proportion of total points you can win, while still winning the set?

Submit your answer as an irreducible fraction, with the numerator and denominator separated by a slash. For example, if your answer is 0.8, you should submit "4/5".

Tennis (Part 2)

Maths

You and your friend are playing a set of tennis. The winner of the set is the first to win 6 games.

Each game is played by standard tennis rules, which will be restated now. A game consists of a series of points, each of which either you or your friend wins. The game ends, and is won by the player who has won more points in the game, when both of the following are true:

- At least one player has won at least 4 points, and
- The difference between the points won by each player is at least 2.

You enjoy teasing your friend, and to do so, you should win the set, but win the lowest proportion of points (across all games) possible. What is the lowest proportion of total points you can win, while still winning the set?

Submit an explanation. The text box should be sufficient, but feel free to link an image on Google Drive or similar if you think it's necessary. **Only submit to this task if you have solved *Tennis: Part 1***, in which you would have found the answer.

Judging and Scoring

Your answer will be judged manually and assigned some percentage of the maximum for this problem. The judging criteria are not public. Only your last submission on each day (AEDT) (if one exists) will be considered. We will strive to judge submissions in a timely manner, but this is not guaranteed. The manual judging system may change at any time depending on what is feasible on our end.

Weakest Link

Programming

Program time limit: 1 second
Program memory limit: 256 MB

Nathan is about to start his Advanced Operating Systems group assignment.

The group consists of N people including Nathan, who must present their findings at the end of the trimester. However, as Nathan is well aware of, how well the group performs depends solely on the intelligence of the worst member on the team.

Nathan has compiled a list of the IQs of every member on his team, and would like to know the following: for every member, what would be the new minimum IQ of the group if that member is removed from the team?

Input

The first line of input contains one integer, N, the number of people in the group.

The next line contains N space-separated integers, the ith of which is a_i, the IQ of the ith member of Nathan's team.

You should read from standard input. If you're unclear about this, see the Input Section of the task "Sandwich".

Constraints

Each input case will satisfy the following constraints:

- $2 \leq N \leq 100\,000$.
- $1 \leq a_i \leq 10^9$, for all i.

Additionally, for 50% of the cases: $N \leq 1000$.

Output

Output N space-separated integers, the ith of which is the new minimum IQ of the group if the ith member were to be removed.

You should write to standard output. If you're unclear about this, see the Input Section of the task "Sandwich".

Sample Input 1

```
3
4 1 2
```

Sample Output 1

```
1 2 1
```

Sample Input 2

```
4
2 2 2 2
```

Sample Output 2

```
2 2 2 2
```

Explanation

In sample case 1:

- If the 1st member is removed, the remaining IQs are 1 and 2, so the minimum remaining IQ is 1.
- If the 2nd member is removed, the remaining IQs are 4 and 2, so the minimum remaining IQ is 2.
- If the 3rd member is removed, the remaining IQs are 4 and 1, so the minimum remaining IQ is 1.

In sample case 2, regardless of who is removed, the minimum remaining IQ will be 2.

Scoring

Your program will be tested on 10 secret input cases one after another. Your score for the submission will be proportional to the amount of test cases for which you output the correct answer.

Squid Game (Part 1)

Maths

In *Squid Game*, a game is played by P players over N turns.

On each turn, one of the following two events happens, with equal probability:

- No players are eliminated.
- One player is eliminated.

The game finishes after N turns are completed, or once all the players are eliminated, whichever comes first. At that point, all the remaining players have won the game.

The logistical details of the game (something to do with glass tiles) are omitted because it is irrelevant to the mathematics of this question.

In order to put on the best show for the VIPs, the organisers want to know the answer to the following question: given that $N = 7$ and $P = 3$, what is the expected value of the number of people who will win?

Submit your answer as an irreducible fraction, with the numerator and denominator separated by a slash. For example, if your answer is 1.8, you should submit "9/5".

Squid Game (Part 2)

Maths

In *Squid Game*, a game is played by P players over N turns.

On each turn, one of the following two events happens, with equal probability:

- No players are eliminated.
- One player is eliminated.

The game finishes after N turns are completed, or once all the players are eliminated, whichever comes first. At that point, all the remaining players have won the game.

The logistical details of the game (something to do with glass tiles) are omitted because it is irrelevant to the mathematics of this question.

In order to put on the best show for the VIPs, the organisers want to know the answer to the following question: given that $N = 10^6$ and $P = 10^6$, what is the expected value of the number of people who will win?

Submit your answer as an irreducible fraction, with the numerator and denominator separated by a slash. For example, if your answer is 1.8, you should submit "9/5".

Squid Game (Part 3)

Maths

In *Squid Game*, a game is played by P players over N turns.

On each turn, one of the following two events happens, with equal probability:

- No players are eliminated.
- One player is eliminated.

The game finishes after N turns are completed, or once all the players are eliminated, whichever comes first. At that point, all the remaining players have won the game.

The logistical details of the game (something to do with glass tiles) are omitted because it is irrelevant to the mathematics of this question.

In order to put on the best show for the VIPs, the organisers want to know the answer to the following question: given that $N = 10^{18}$ and $P = 5 \times 10^{17}$, what is the expected value of the number of people who will win?

Submit your answer in scientific notation to 3 significant figures, using the character "e" to separate the coefficient and the exponent. For example, if your answer is 2022, you should submit "2.02e3".

Advertising

Programming

Program time limit: 1 second
Program memory limit: 256 MB

CPMSoc is planning to launch its biggest coding competition ever. Help us put up a poster that's sure to get the word out!

The poster is to be placed on a rectangular wall, which can be thought of as an integer grid of width W and height H. The poster needs to be rectangular in shape, with its sides parallel to the grid lines.

There are already N pieces of blutack placed onto the wall, the ith of which is at the coordinates (x_i, y_i), meaning that it is placed x_i units from the left edge of the wall, and y_i units from the bottom edge of the wall.

To get as much attention as possible, CPMSoc would like to maximise the area of the poster it puts up. However there is a catch: both the top left corner and the bottom right corner of the poster must be precisely placed on a piece of blutack. Note that as long as this condition is met, it does not matter how many other pieces of blutack the poster is placed on top of.

What's the largest area of any rectangular poster that CPMSoc can put up that follows the above constaints?

Input

The first line consists of 3 space-separated integers W, H and N, which are the width of the wall, the height of the wall, and the number of pieces of blutack on the wall, respectively.

Next follow N lines, the ith of which contains 2 space-separated integers, x_i and y_i, representing the coordinates of the ith piece of blutack.

You should read from standard input. If you're unclear about this, see the Input Section of the task "Sandwich".

Constraints

Each input case will satisfy the following constraints:

- $1 \leq W, H \leq 10^9$.
- $2 \leq N \leq 200\,000$.
- $0 \leq x_i \leq W$ for all i.
- $0 \leq y_i \leq H$ for all i.

For 30% of the points, $N \leq 1000$.
For another 30% of the points, $W, H \leq 1000$.
For the final 40% of points, there are no additional constraints.

Output

Output a single integer, representing the largest area of a poster that CPMSoc can place following the above constraints. If there is no way to place a poster, output 0.

You should write to standard output. If you're unclear about this, see the Input Section of the task "Sandwich".

If using C or C++, note that the answer may exceed that which fits in an `int`, so you are advised to use a `long long`.

Sample Input 1

```
4 5 4
3 1
2 3
1 4
2 5
```

Sample Output 1

```
6
```

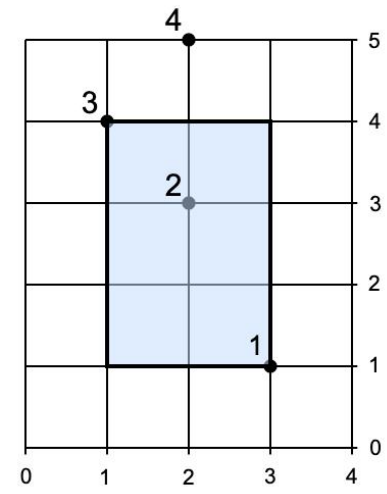
Sample Input 2

```
3 3 3
0 0
3 0
3 3
```

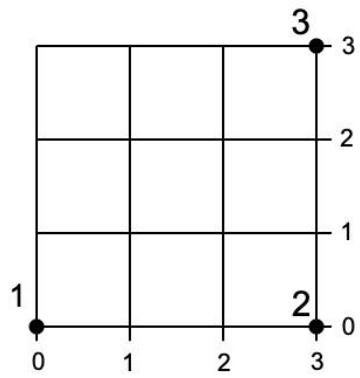
Sample Output 2

```
0
```

Explanation



In sample case 1, we place the poster with top left corner on blutack 3 and bottom right corner on blutack 1 for an area of 6.



In sample case 2, there is no way to place a poster such that its top left corner and bottom right corner both lie on a piece of blutack. Hence, we output 0.

Scoring

For each set of constraints (worth 30%, 30%, and 40%; see the Constraints section), your program will be tested on multiple secret input cases one after another. Your score for the submission will correspond to the sets of constraints for which your program passes **all the cases**. Recall that your final score on the problem is the score of your highest scoring submission.

Cooked Sum

Maths

Find a simple expression in n equivalent to

$$\sum_{k=1}^{n-1} \binom{n}{k} k^{k-1} (n-k)^{n-k-1}.$$

Submit an answer and an explanation. Feel free to link an image on Google Drive or similar if you think it's necessary.

Judging and Scoring

30% of this problem is awarded for providing a correct expression, and the remaining 70% is awarded for providing a correct proof.

Your answer will be judged manually and assigned some percentage of the maximum for this problem. The judging criteria (other than what's stated above) are not public. Only your last submission on each day (AEDT) (if one exists) will be considered. We will strive to judge submissions in a timely manner, but this is not guaranteed. The manual judging system may change at any time depending on what is feasible on our end.