

Programming Question 1

DUE: Friday, February 14, 11:59 PM. DO NOT COPY.

Please read the course outline (on LEARN) for general assignment instructions and policies.

Tower Domination

There are n towers defined by their integer coordinates x_i and y_i , $i = 1, 2, \dots, n$. We say that a tower i *dominates* a tower j if and only if

$$(x_i > x_j) \wedge (y_i > y_j) \vee (x_i < x_j) \wedge (y_i < y_j).$$

That is, the coordinates of tower i are either both greater, or both smaller, than the coordinates of tower j . Define the *dominance factor* of tower i as the total number of towers dominated by it. Your task is to design a **divide-and-conquer** algorithm to compute the dominance factor of each tower.

Input Format: The first line of input is an integer n , the number of towers. n lines follow. The i -th of these lines consists of two space-separated integers x_i and y_i , the coordinates of tower i .

Output Format: Output a line of n space-separated integers, the i -th integer being the dominance factor of tower i .

Constraints: For all test cases, $1 \leq n \leq 2 \times 10^5$, $-10^9 \leq x_i, y_i \leq 10^9$ for $i = 1, \dots, n$. In addition, $x_i \neq x_j$ and $y_i \neq y_j$ for all $i \neq j$.

Sample input

```
4
3 3
4 2
5 6
2 1
```

Sample output

```
2 2 3 3
```

Submission guidelines:

- Submit your program on Marmoset (<https://marmoset.student.cs.uwaterloo.ca>)
- Write your program in C++ (version is C++20) and submit it as `prog1.cpp`.
- Compilation command: `g++ -std=c++20 prog1.cpp -O3 -o prog1`

- Test cases: there will be some number of public tests and secret tests. The public tests are worth 6 points and the secret tests are worth 24 points, for a total of 30 points. Different test cases may carry a different amount of points. The public tests will be available for download on the course website.
- The time limit for each test case is **2 seconds**.
- Marmoset “time limit of 60s exceeded” message is the default message and does not reflect the actual time limit. Please see the long result instead.
- Scoring: your score will be the highest score among all your submissions. Do, however, refrain from excessive submissions.
- The core of your solution must be a divide-and-conquer algorithm. Submissions that are not divide-and-conquer in nature, if found out, will receive a score of **zero**.
- It is prohibited to share code or public test outputs. If you wish to seek help on Piazza regarding your program, ask a private question.
- If you are not added to CS341 Marmoset yet, please contact Sylvie (sldavies@uwaterloo.ca).