Freshmen Programming Contests 2025

Solutions presentation

By the Freshmen Programming Contests 2025 jury for:

- AAPJE in Amsterdam
- FPC in Delft
- FYPC in Eindhoven
- GAPC in Groningen
- Contest in Mons

May 3, 2025

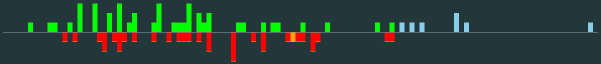
Other universities will have their contests in the coming weeks.

Please, do not post/discuss the problems online before

Saturday 17 May 2025 at 17:00

G: Gambler’s Dilemma

Problem author: Wietze Koops



Problem: Determine whether two playing cards have any of the four given properties.

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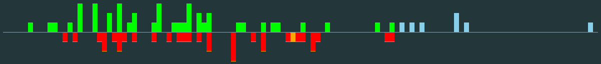

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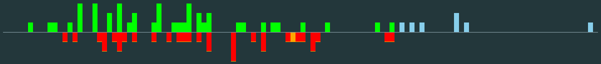

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Pitfall: Be careful of off-by-one errors when calculating the rank of a card.

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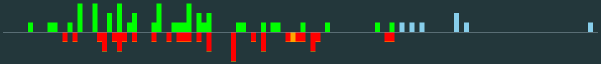

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Running time: $\mathcal{O}(1)$.

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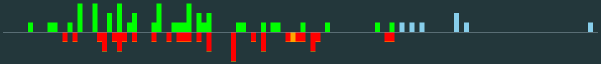

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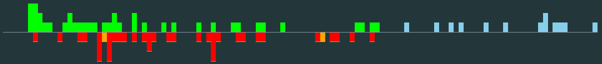
Running time: $\mathcal{O}(1)$.

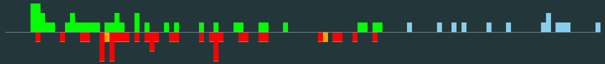
Statistics: 82 submissions, 42 accepted, 7 unknown



Problem: Minimize the area of one rectangle that cannot overlap with another.

B: Bakfiets

Problem author: Jeroen Op de Beek



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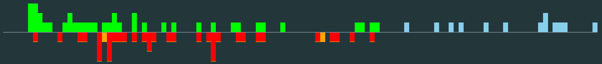

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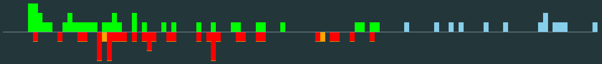

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Solution: Compute $w \cdot h - \max(\min(w, a) \cdot \min(h, b), \min(w, b) \cdot \min(h, a))$.

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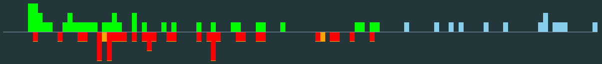

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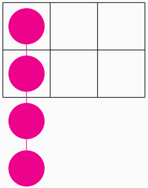

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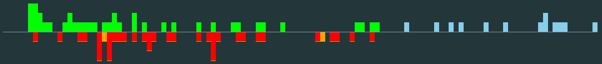

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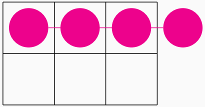

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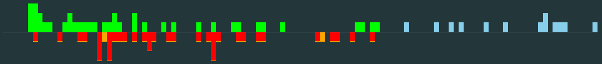

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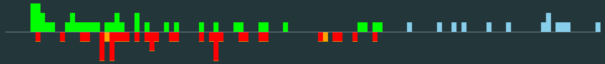

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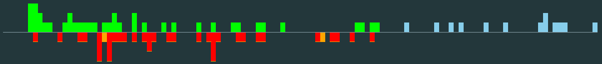

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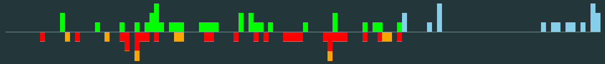
Running time: $\mathcal{O}(1)$.

Statistics: 90 submissions, 39 accepted, 13 unknown

J: Jumbled Keys

Problem author: Arnoud van der Leer



Problem: Decipher a message, using a series of mapped words.

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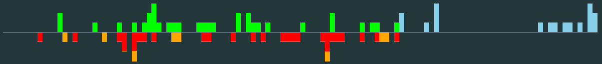

Problem: Decipher a message, using a series of mapped words.

Solution: Use a map! Process every pair of words, and map every letter in the first word to the letter it corresponds to in the second word.

Edge case: If 25 letters are mapped, the 26th letter maps to the only letter that has no other letter mapped to it.

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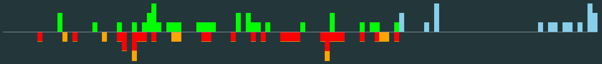

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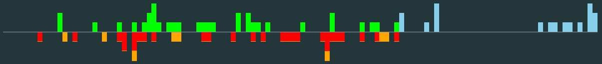

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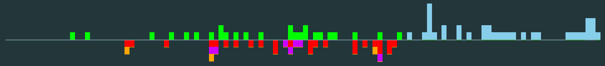
Running time: $\mathcal{O}(n \cdot \ell)$, where ℓ is the average length of the words.

Statistics: 86 submissions, 33 accepted, 17 unknown

H: Hopelessly Hungover

Problem author: Wietze Koops



Problem: Each weekday you can learn k facts, each day in the weekend you forget m facts. Given a starting day of the week, how many days do you need to wait before you know all n facts?

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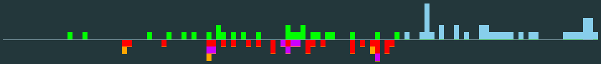

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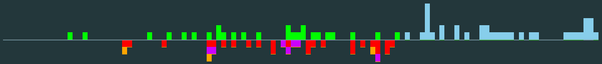

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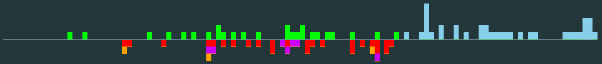

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Solution: We can simulate the process for $7n + 14$ days. Whenever the number of facts is n we stop. After $7n + 14$ days we can be sure that we will never learn all n facts.

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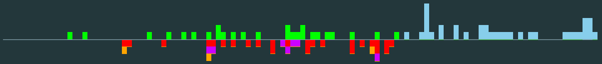

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Fun fact: The actual maximum number of days you have to wait is 6976.

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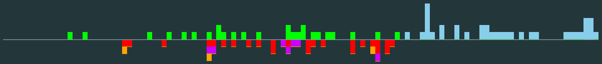

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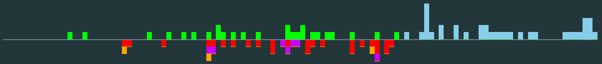

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Pitfall: It is possible to solve this problem in $O(1)$ by case-working on the ending day, and using formulas involving ceil division. This solution is prone to mistakes.

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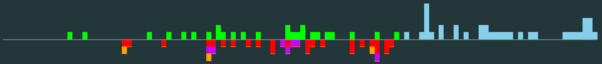

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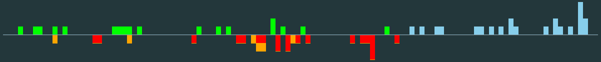
Statistics: 97 submissions, 26 accepted, 36 unknown

A: Array Annihilation

Problem author: Leon van der Waal



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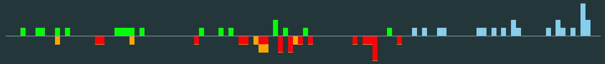

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Observation: Every value in the array needs to be decremented along with either of its neighbours. So for each position i, it is necessary that $a_i \geq a_{i-1} + a_{i+1}$.

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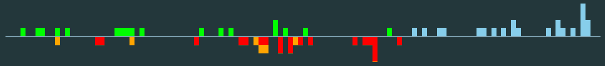

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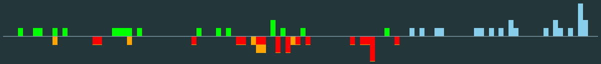

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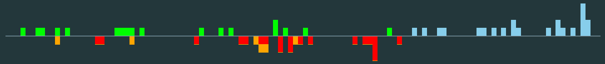

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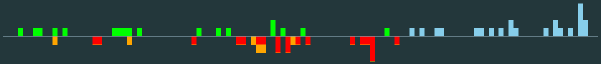

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Proof: It's clear the condition is necessary. We need to show that it's sufficient.

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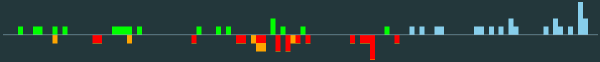

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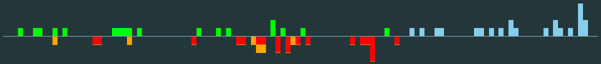

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- It's sufficient to restrict use to length-2 and length-3 segments only.
- The total number of length-2, length-3 segments starting at 1 is a_1.

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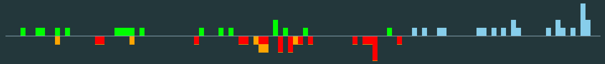
Problem author: Leon van der Waal



Problem: Given an array, is it possible to make all values equal to 0 when repeatedly decrementing two or more consecutive values in the array.

Solution: If $a_i \geq a_{i-1} + a_{i+1}$ holds for each triplet of positions in the array: "`possible`". Else: "`impossible`".

Proof: It's clear the condition is necessary. We need to show that it's sufficient.

- It's sufficient to restrict use to length-2 and length-3 segments only.
- The total number of length-2, length-3 segments starting at 1 is a_1.
- Those segments cover $[1, 2]$ or $[1, 2, 3]$. This means a_2 -= a_1, a_3 -= δ, where $\delta \in [0, a_1]$.

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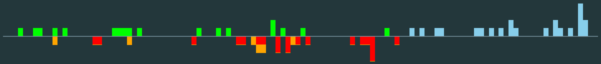

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- If the original $a_1, \ldots, a_n$ satisfied condition, one can select δ such that $a_2 - a_1, a_3 - \delta, a_4, \ldots, a_n$ satisfies the condition.

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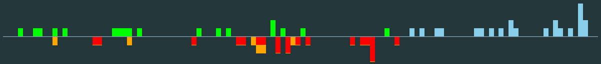

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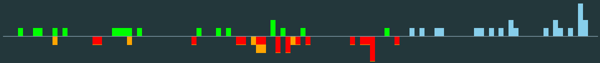

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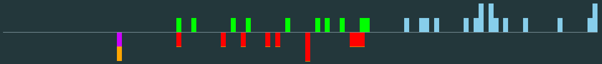
Statistics: 66 submissions, 18 accepted, 22 unknown

D: Delicious Trees

Problem author: Jeroen Op de Beek



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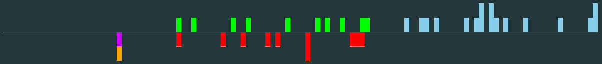

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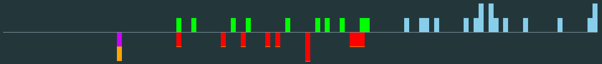

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Solution: First calculate the depth of each vertex in the tree using BFS/DFS, then remove vertices one-by-one from largest to smallest depth.

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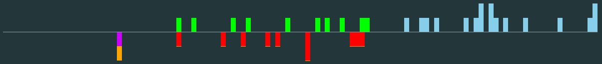

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Red herring: The first sample cuts off larger AVL trees on purpose.

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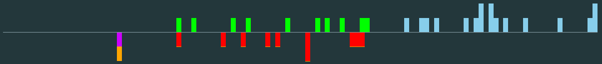

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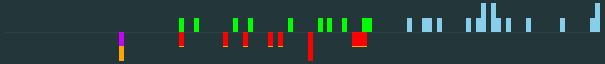

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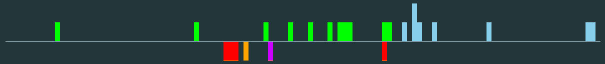
Statistics: 39 submissions, 10 accepted, 17 unknown

E: Equation Extrapolation

Problem author: Jeroen Op de Beek



Problem: Recover the coefficients of a hidden polynomial $P(x)$ using at most 9 queries.

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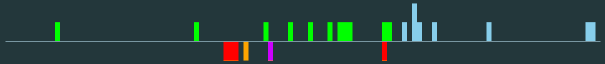

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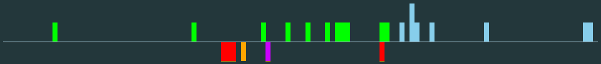

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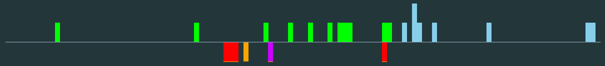

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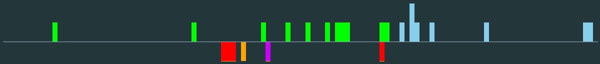

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Fun fact: Can be solved in one very short line of Python!

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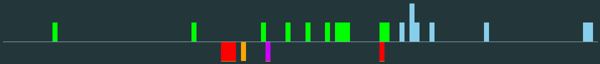

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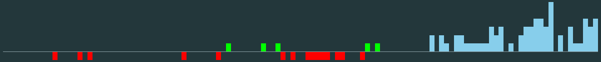
Statistics: 25 submissions, 11 accepted, 8 unknown

F: Frog and Princess

Problem author: Wietze Koops



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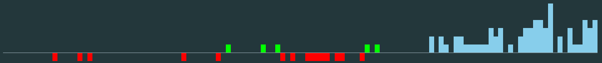

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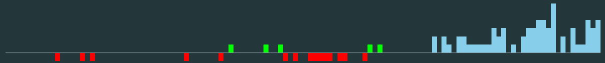

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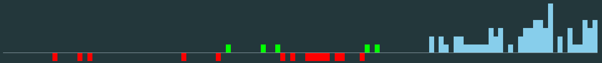

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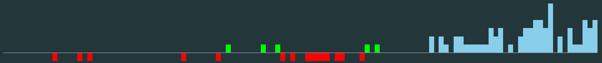

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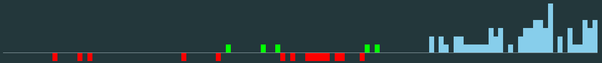

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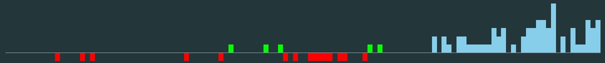

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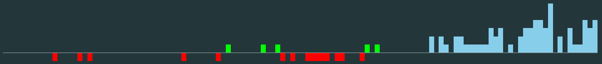

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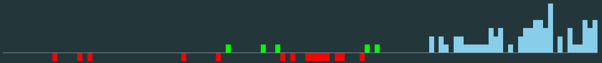

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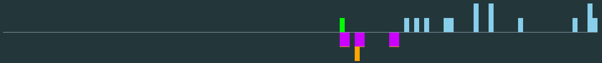
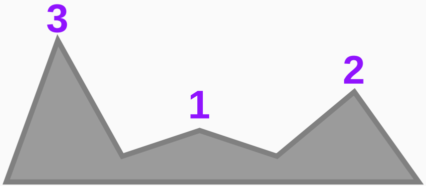
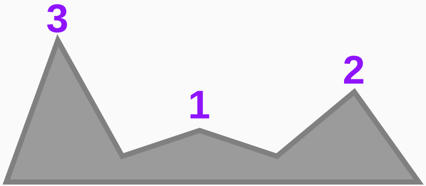




Problem: Calculate the number of “interesting formations”.



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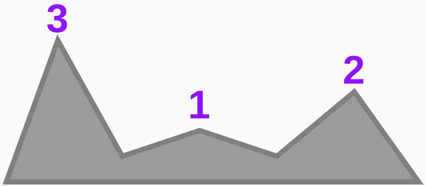
Observation 1: This is similar to counting **inversions**.



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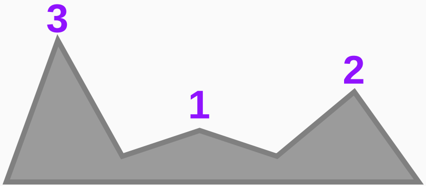

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Let's first learn how to count **inversions**.

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We maintain a datastructure that supports range queries.

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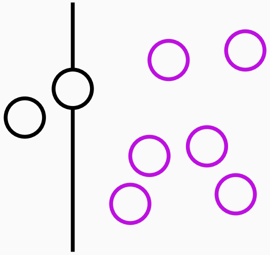

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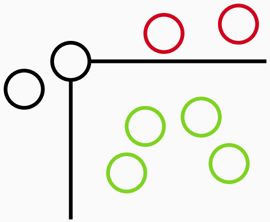

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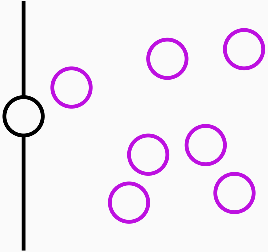

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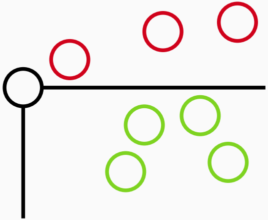

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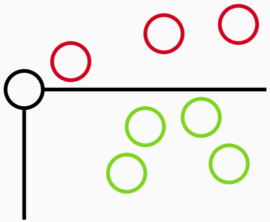
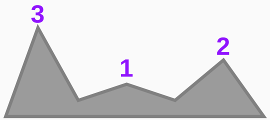


Using Fenwick tree or segment tree, $\mathcal{O}(\log(n))$ per query / update.



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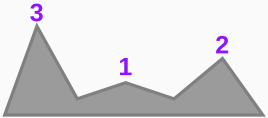

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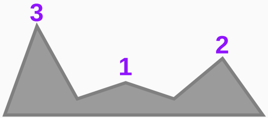

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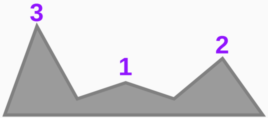

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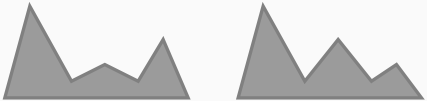

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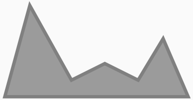

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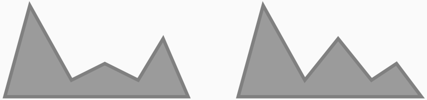

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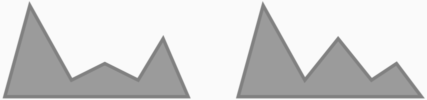

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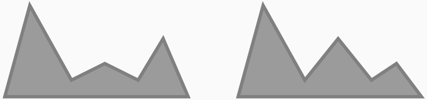

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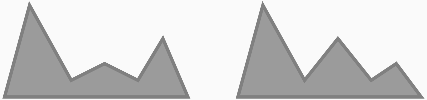

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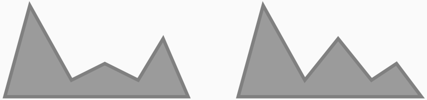

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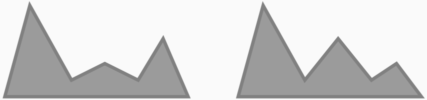

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Statistics: 22 submissions, 1 accepted, 14 unknown

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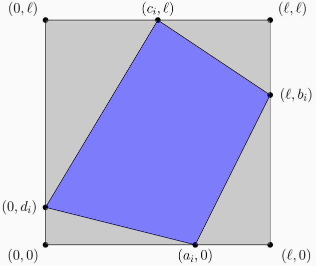
Solution: Let $(a_i, 0)$, (ℓ, b_i), (c_i, ℓ) and $(0, d_i)$ be the coordinates of the corners of the ith quadrilateral. Then we can compute the sum of the areas by considering how much is cut off from the full $\ell \times \ell$ square:

$$\sum_{i=1}^{n} \left(\ell^2 - \tfrac{1}{2}a_i d_i - \tfrac{1}{2}(\ell - a_i)b_i - \tfrac{1}{2}(\ell - b_i)(\ell - c_i) - \tfrac{1}{2}c_i(\ell - d_i)\right).$$



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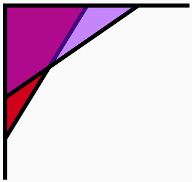

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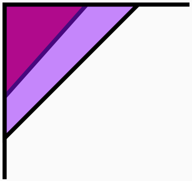

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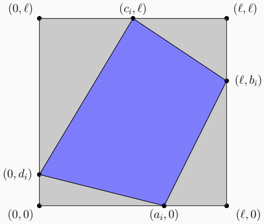

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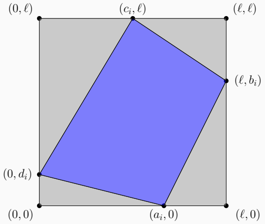

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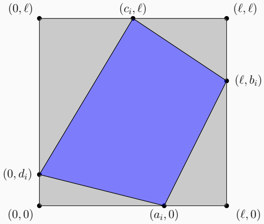

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Statistics: 7 submissions, 0 accepted, 7 unknown

Problem: For every divisor d of n, find the minimum number of changes to make $t = t' \odot d$ for some string t'.

C: Characterithmetic

Problem author: Jeroen Op de Beek

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Observation 1: $n \leq 10^5$, so there can be at most 128 different divisors of n.

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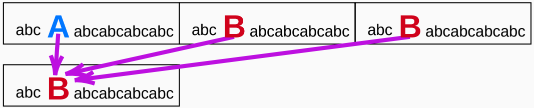


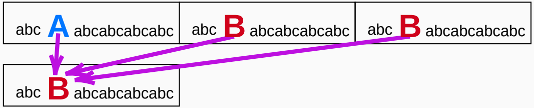
Problem author: Jeroen Op de Beek

Problem: For every divisor d of n, find the minimum number of changes to make $t = t' \odot d$ for some string t'.

Observation 1: $n \leq 10^5$, so there can be at most 128 different divisors of n.

Naive solution:

- Handle each divisor d separately.
- For each position in t', pick the character that occurs most often.



- Then count how many letters we must have changed.

C: Characterithmetic

Problem author: Jeroen Op de Beek

Problem: For every divisor d of n, find the minimum number of changes to make $t = t' \odot d$ for some string t'.

WA: But what if there is a larger divisor!?

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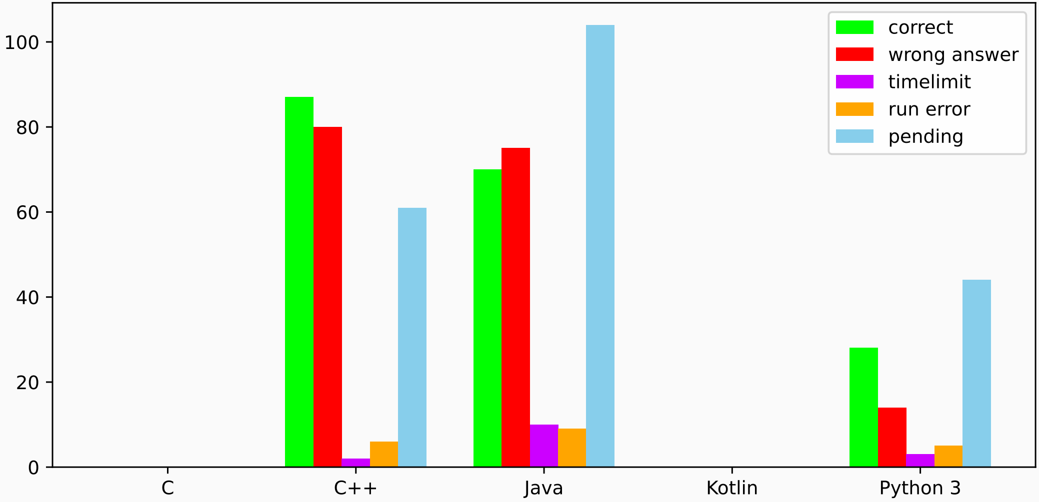
Statistics: 2 submissions, 0 accepted, 2 unknown

Language stats



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Jury work

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- 625 secret test cases (last year: 357)
- 160 accepted jury/proofreader solutions (last year: 120)
- The minimum[1] number of lines the jury needed to solve all problems is

$$2 + 1 + 6 + 5 + 1 + 5 + 2 + 2 + 6 + 3 + 6 = 39$$

On average 3.5 lines per problem, down from 6.0 last year

[1] *After* codegolfing

Thanks to the proofreaders:

- Arnoud van der Leer (TU Delft)
- Dany Sluijk (TU Delft)
- Davina van Meer (Delft)
- Mattia Marziali (RU Groningen)
- Michael Zündorf 🎈 (KIT Karlsruhe / NWERC jury)
- Pavel Kunyavskiy (JetBrains Amsterdam)
- Pierre Vandenhove (UMons)
- Thomas Verwoerd (TU Delft, Kotlin Hero 🎈)
- Thore Husfeldt (ITU Copenhagen / BAPC Jury)
- Wendy Yi (KIT Karlsruhe / NWERC jury)

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- Alice Sayutina (VU Amsterdam)
- Angel Karchev (TU Delft)
- Bálint Kollmann (TU Delft)
- Jeroen Op de Beek (TU Delft)
- Leon van der Waal (TU Delft)
- Liudas Staniulis (VU Amsterdam)
- Maarten Sijm (TU Delft)
- Mihail Bankov (TU Delft)
- Moham Balfakeih (TU Delft)
- Wietze Koops (Radboud Nijmegen / RU Groningen)

Open online contest

Want to solve the problems you could not finish?
Or have friends that like to solve algorithmic problems?

`https://fpcs2025.bapc.eu/`

Saturday 17 May 2025 13:00–17:00

Please, do not post/discuss the problems online before this time!

Future contest fun

Excited to participate in the next contest?

Register for DAPC (20 September) at `wisv.ch/dapc`

Want to organize these contests?

Join the CHipCie: `wisv.ch/chipcieinterest`

Want to create programming problems for FPC next year?

Either join the CHipCie, or contact Maarten Sijm