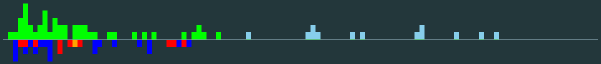
DAPC 2022

Solutions presentation

September 30, 2022

L: Lots of Liquid

Problem Author: Maarten Sijm



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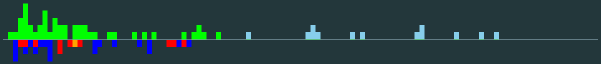

- **Problem:** Find the length of the side of a cube that contains all liquid.
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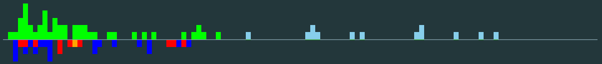

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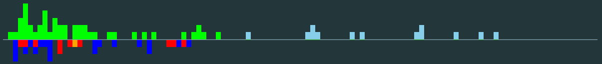

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Statistics: 97 submissions, 46 accepted, 13 unknown

F: Fastestest Function

Problem Author: Ragnar Groot Koerkamp

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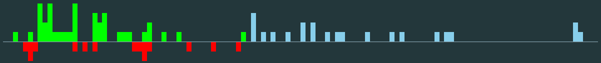

- **Problem:** Given that `foo` took $x\%$ of the total run time before optimizing and $y\%$ after, what is the factor of how much faster `foo` got?
- **Observation:** We can express this problem as the following equations:

$$\frac{\text{old time }\texttt{foo}}{\text{old time }\texttt{foo} + \text{other time}} = x\% \qquad \frac{\text{new time }\texttt{foo}}{\text{new time }\texttt{foo} + \text{other time}} = y\%$$

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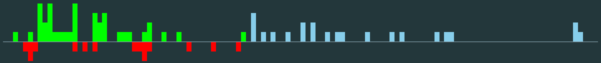

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$$\text{factor} = \frac{\text{old time } \texttt{foo}}{\text{new time } \texttt{foo}} = \frac{x \cdot (1 - y)}{y \cdot (1 - x)}$$

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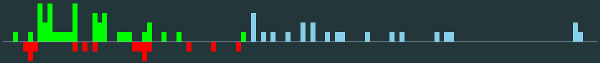

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Statistics: 74 submissions, 37 accepted, 22 unknown

B: Bubble-bubble Sort

Problem Author: Ragnar Groot Koerkamp

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- **Optimized:**
  - Observe that high numbers move to the right immediately, and low numbers move $k-1$ to the left per iteration.
  - Solution: find the maximum distance (to the left) of any value to their sorted position (D), and output $\left\lceil \frac{D}{k-1} \right\rceil$.
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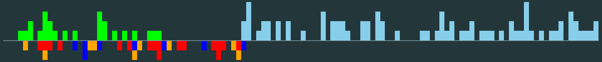
Statistics: 73 submissions, 29 accepted, 27 unknown

A: Abbreviated Aliases

Problem Author: Ragnar Groot Koerkamp



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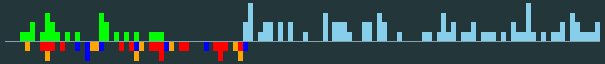

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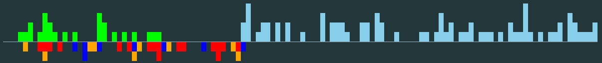

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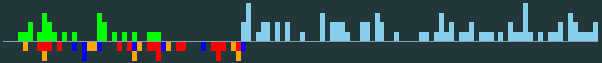

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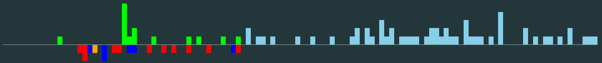
Statistics: 154 submissions, 25 accepted, 77 unknown

E: Extended Braille

Problem Author: Wessel van Woerden



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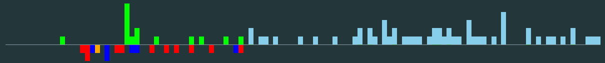

- **Problem:** Given n braille characters by their points, determine how many of them are distinct up to translation.
- **To compare two characters:** For each character $P = \{p_1, \ldots, p_m\} \subset \mathbb{Z}^2$ sort its points lexicographically such that $p_1 < \ldots < p_m$. For two sorted characters P, Q check if all points differ by the same translation: $p_1 - q_1 = \ldots = p_m - q_m$.
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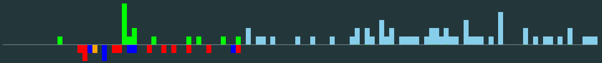

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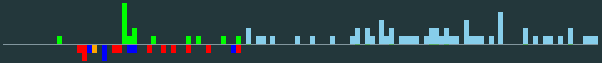

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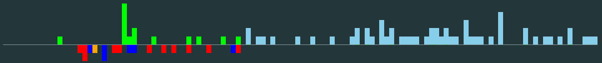

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Statistics: 91 submissions, 14 accepted, 56 unknown

C: Cookbook Composition

Problem Author: Timon Knigge

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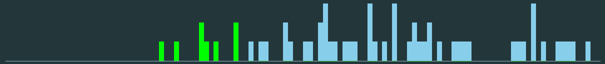
Statistics: 111 submissions, 10 accepted, 87 unknown

K: Knitting Patterns

Problem Author: Maarten Sijm



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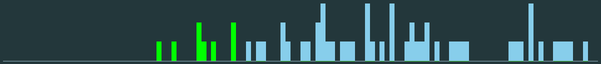

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- **Observation:** Between two times a colour of wool is used, you either leave the strand through the back unused for the entire gap, or you immediately end the use at the beginning of the gap and start using it at the end.
- **Solution:** For every colour, iterate through the knitting pattern and remember the index of the last time the colour occurred. If you encounter the colour again, the marginal cost is the minimum between leaving the strand unused the whole time since the last time, and the sum of the costs for ending and starting. Runs in $\mathcal{O}(|w| \cdot n)$.

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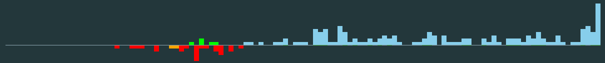
Statistics: 58 submissions, 8 accepted, 50 unknown

J: Jabbing Jets

Problem Author: Abe Wits



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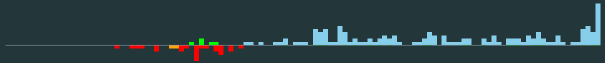

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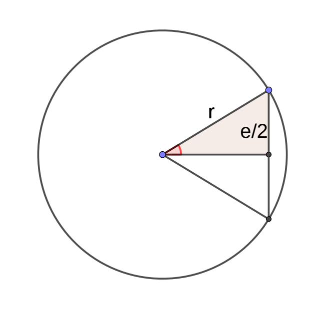

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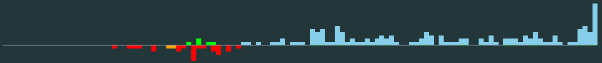

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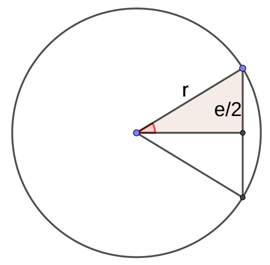
- Edge case: if $2r_i < e$, the number of points is 1.



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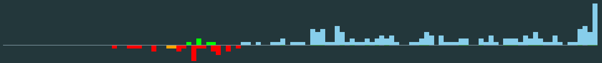

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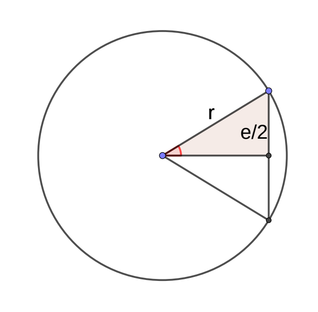

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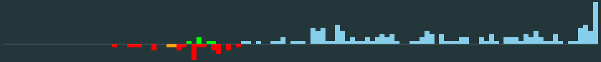

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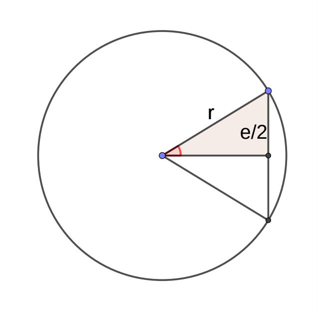
  - Add $0.5 \cdot 10^{-6}$ to every radius.



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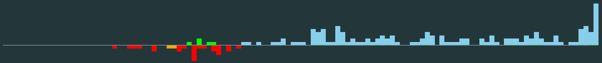

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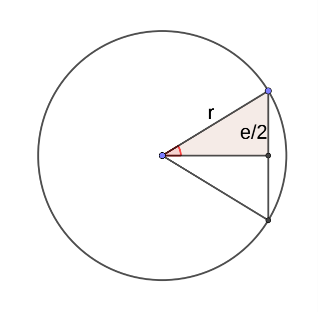
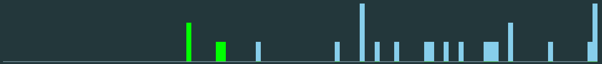


- Edge case: if $2r_i < e$, the number of points is 1.
- Beware floating point issues!
  - Add $0.5 \cdot 10^{-6}$ to every radius.

Statistics: 168 submissions, 5 accepted, 137 unknown

D: Dimensional Debugging

Problem Author: Ragnar Groot Koerkamp



- **Problem:** Given n algorithms that only work when their input $\vec{x}$ is small enough ($\vec{x} \leq \vec{H}$), can you verify the correctness of all of them on sufficiently large inputs ($\vec{x} \geq \vec{L}$)?

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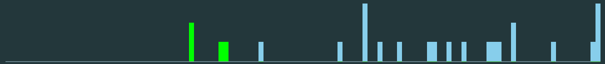

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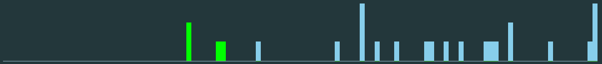

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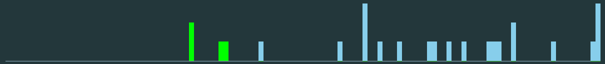

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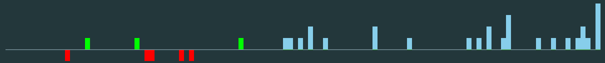
Statistics: 25 submissions, 4 accepted, 21 unknown

I: Inked Inscriptions

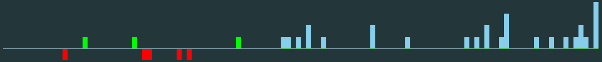
Problem Author: Ragnar Groot Koerkamp



- **Problem:** Copy n psalms in at most $2n\sqrt{n}$ pageflips.

I: Inked Inscriptions

Problem Author: Ragnar Groot Koerkamp



- **Problem:** Copy n psalms in at most $2n\sqrt{n}$ pageflips.
- Most naive solutions use $\mathcal{O}(n^2)$ pageflips, so you need to be smarter.

I: Inked Inscriptions

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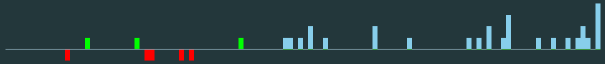

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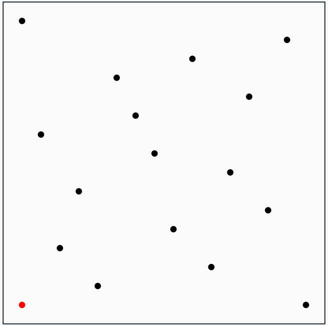

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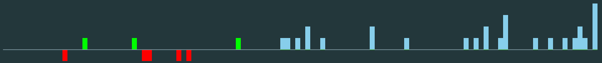

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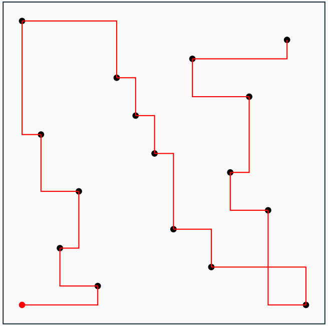
- So, you need to find a path of bounded length that visits all points.



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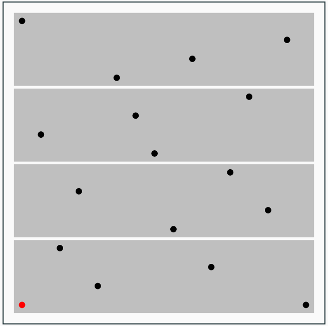

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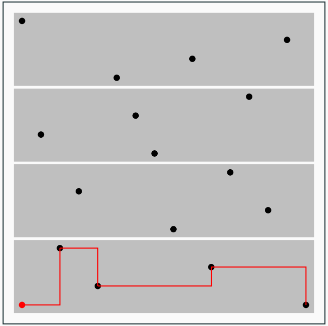

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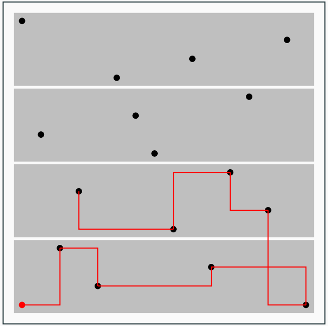

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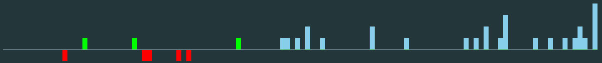

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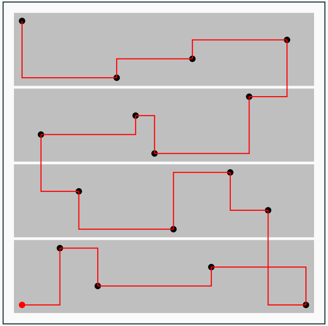
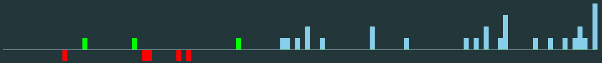
- And so on...





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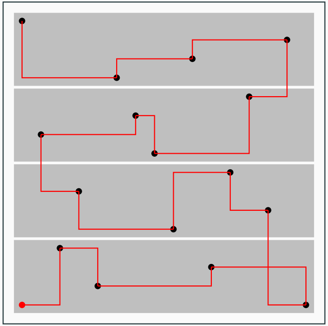

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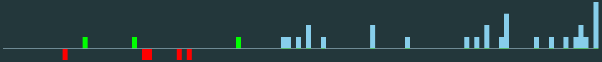

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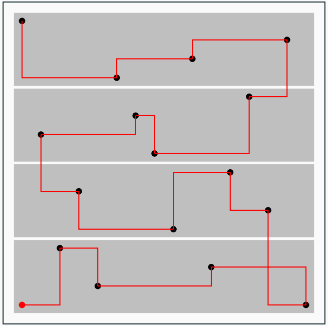

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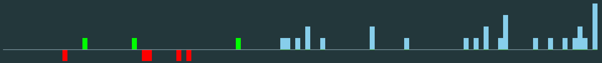

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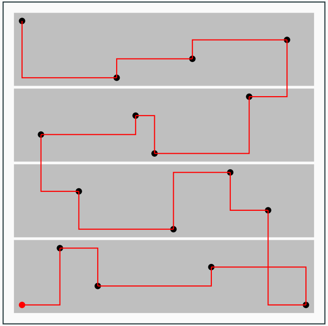
- Overall: this uses at most $\sqrt{n}(n + n/2) + 2n = 1.5n\sqrt{n} + 2n$ page flips.



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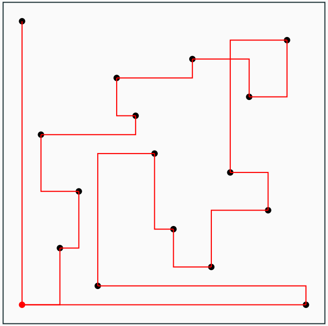

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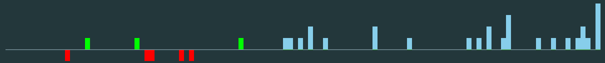

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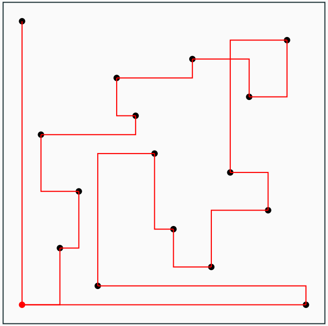

Statistics: 36 submissions, 3 accepted, 28 unknown

G: Guessing Primes

Problem Author: Ludo Pulles

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- This is guaranteed to succeed in 6 guesses:
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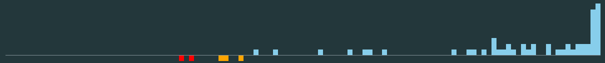

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Statistics: 59 submissions, 0 accepted, 54 unknown

H: Heavy Hauling

Problem Author: Ragnar Groot Koerkamp

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- **Observation:** Groups of consecutive boxes map to an interval.
- The cost of moving a box from position p to a position x, can be modelled with a quadratic function $C_p(x) = (x - p)^2$.
  - Example: For one box with original position 3 moved to position x, $C_3(x) = (x - 3)^2 = x^2 - 6x + 9$.

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- When adding the costs of two groups of boxes that overlap together, *translate* the cost function of the right group of boxes by the size of the left group.
  - Example: For two boxes with original position 3, moved such that the left-most box is at position x, the summed cost is $C_{3,3}(x) = C_3(x) + C_3(x + 1) = (x - 3)^2 + (x - 2)^2 = 2x^2 - 10x + 13$.

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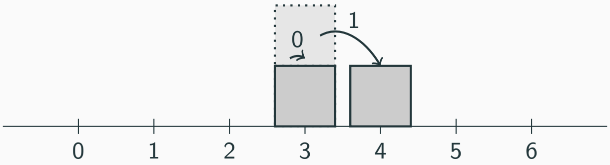
- The cost of a box at a position x, starting at position p, can be modelled with a quadratic function $C_p(x) = (x - p)^2$.
  - For two boxes that start at position 3, the summed cost is $C_{3,3}(x) = C_3(x) + C_3(x+1) = (x-3)^2 + (x-2)^2 = 2x^2 - 10x + 13$.

Proof by example:



$$C_{3,3}(3) = 2 \cdot 3^2 - 10 \cdot 3 + 13 = 1$$

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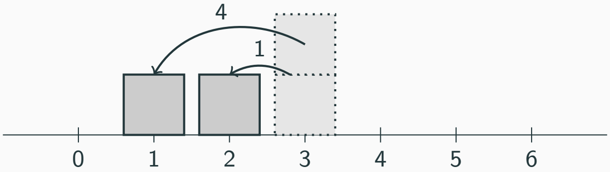

$$C_{3,3}(1) = 2 \cdot 1^2 - 10 \cdot 1 + 13 = 5$$

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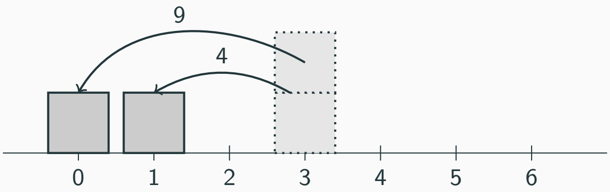

$$C_{3,3}(0) = 2 \cdot 0^2 - 10 \cdot 0 + 13 = 13$$

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- **Solution:** Add every box from left to right, maintaining the optimal placement by maintaining the cost function for every group of boxes.

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- If two groups of boxes touch or overlap, merge them into one group by summing their (possibly translated) costs.
  - This new group may overlap with its preceding group after the merge, so merge recursively.
- For every group with cost $C(x) = ax^2 + bx + c$, the minimal cost is:

$$C\left(\left\lfloor \frac{-b}{2a} + \frac{1}{2} \right\rfloor\right)$$

H: Heavy Hauling

Problem Author: Ragnar Groot Koerkamp

- **Problem:** Given n boxes at given positions. Moving a box d positions costs d^2.
  What is the minimal cost to make all box positions distinct?
- **Solution:** Add every box from left to right, maintaining the optimal placement by maintaining the cost function for every group of boxes.
- If two groups of boxes touch or overlap, merge them into one group by summing their (possibly translated) costs.
  - This new group may overlap with its preceding group after the merge, so merge recursively.
- For every group with cost $C(x) = ax^2 + bx + c$, the minimal cost is:

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- The total runtime is $\mathcal{O}(n)$ (after sorting): we do at most $n-1$ merges.

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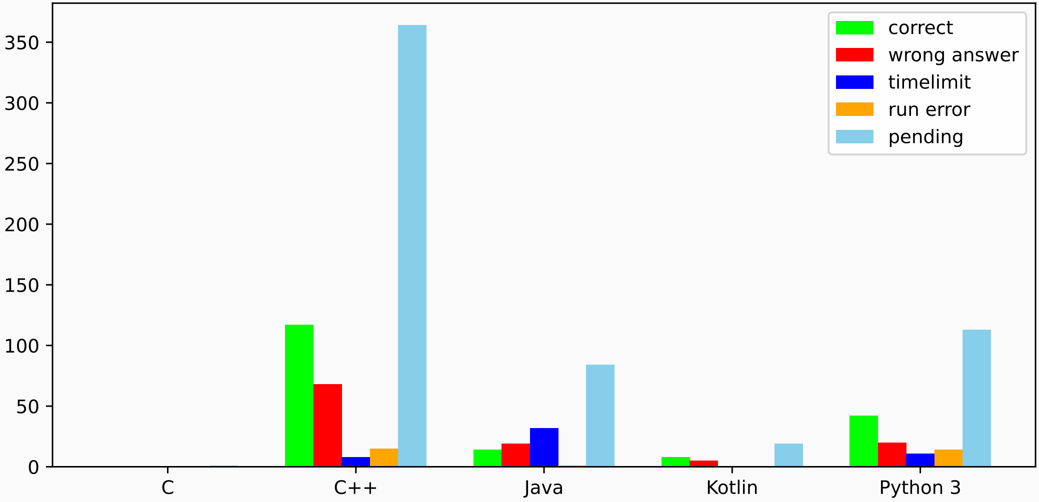
Statistics: 10 submissions, 0 accepted, 9 unknown

Language stats



ETV Board also did their best!

Random facts

Jury work

- 298 commits

[1] *After* codegolfing

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- 153 jury + proofreader solutions
- The minimum[1] number of lines the jury needed to solve all problems is

$$5 + 3 + 8 + 9 + 3 + 2 + 25 + 9 + 3 + 4 + 6 + 2 = 79$$

On average 6.6 lines per problem, down from 7.5 in last year's preliminaries

[1] *After* codegolfing

Thanks to:

The proofreaders

Jaap Eldering
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The jury

Boas Kluiving
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Ragnar Groot Koerkamp
Reinier Schmiermann
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Wessel van Woerden