

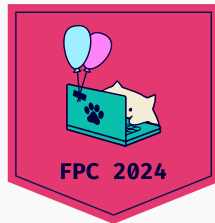
Freshmen Programming Contests 2024

Solutions presentation

By the Freshmen Programming Contests 2024 jury for:

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

May 4, 2024



A: Annoying Alliterations

Problem author: Maciek Sidor



- **Problem:** Given n words, find a pair such that after their common prefix is removed, the sum of lengths of the two resulting words is the greatest.

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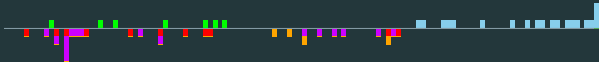
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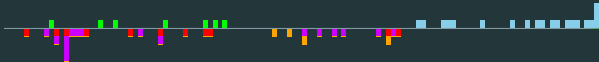
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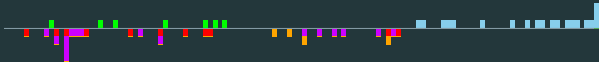
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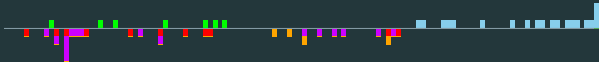
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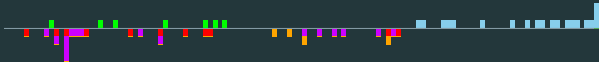
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- Similarly, $|p(v, t)| > |p(s, t)|$, but these two together give us a contradiction. \square

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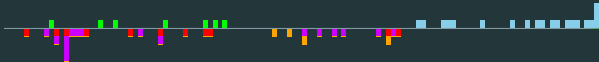
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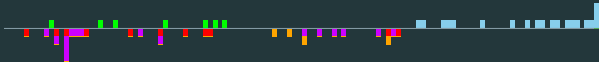
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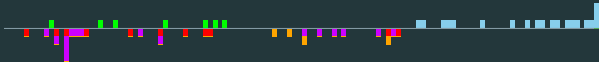
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Statistics: 58 submissions, 7 accepted, 20 unknown

B: Building Pyramids

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Statistics: 75 submissions, 36 accepted, 1 unknown

C: Curious Jury

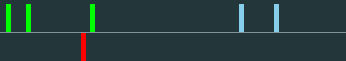
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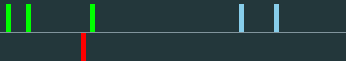
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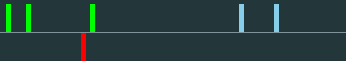
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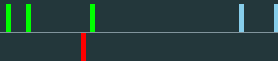
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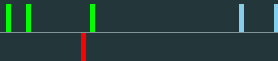
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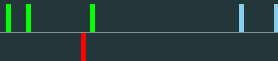
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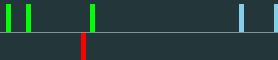
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- Team j is in group **C** if $l_j \geq f$.
- Otherwise, team j is in **B**. By sorting the l_j and s_j arrays, $|A|$ and $|C|$ can be found by binary search.

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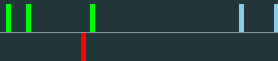
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- Complexity varying from $\mathcal{O}(n(\log(n) + \log(MOD)))$ to $\mathcal{O}(n + \log(MOD))$ depending on exact implementation.



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- Now fill the array invfactorial[k] using invfactorial[k] = invfactorial[$k+1$] \cdot ($k+1$) in $\mathcal{O}(n)$.
- Complexity varying from $\mathcal{O}(n(\log(n) + \log(MOD)))$ to $\mathcal{O}(n + \log(MOD))$ depending on exact implementation.

Statistics: 6 submissions, 3 accepted, 2 unknown

D: Dragged-out Duel

Problem author: Wietze Koops



- **Problem:** Read two lines, comprised of 'R', 'P', and 'S', and determine who wins the most games.

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 - Read the two lines character by character, increment a counter if player 1 wins and decrement it if player 2 wins.
 - Finally, print "victory" if the counter is positive, and "defeat" if it is negative.

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- **Complexity:** $\mathcal{O}(n)$.

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 - Finally, print "victory" if the counter is positive, and "defeat" if it is negative.
- **Complexity:** $\mathcal{O}(n)$.

Statistics: 45 submissions, 37 accepted

E: European Election

Problem author: Veselin Mitev



- **Problem:** Given ranked-choice ballots, determine the candidate who beats all other candidates.

E: European Election

Problem author: Veselin Mitev



- **Problem:** Given ranked-choice ballots, determine the candidate who beats all other candidates.
- **Fun Fact:** This is also known as the *Condorcet* voting method.

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- **Fun Fact:** This is also known as the *Condorcet* voting method.
- How to determine whether candidate A is better than B?
 - Go through all ballots – count how many times A appears before B, and vice-versa. Runs in $\mathcal{O}(n \cdot k)$.

E: European Election

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- **Observation:** We can preprocess the ballots in $\mathcal{O}(n \cdot k)$, such that we can access the position that each candidate appears in each ballot in $\mathcal{O}(1)$. Thus, answering whether candidate A beats candidate B, now only takes $\mathcal{O}(n)$.

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 - Pick a candidate d .

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 - Check if d beats all other candidates. Runs in $\mathcal{O}(n \cdot k)$.
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 - But we chose the time limit to also accept $\mathcal{O}(n \cdot k^2)$ or even $\mathcal{O}(n \cdot k^3)$.

E: European Election

Problem author: Veselin Mitev

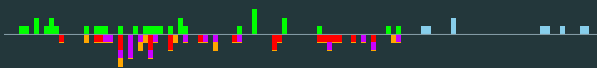


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Statistics: 50 submissions, 15 accepted, 21 unknown

F: Flag Rotation

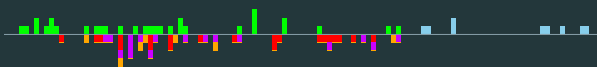
Problem author: Jeroen Op de Beek



- **Problem:** Count how many cells will change when painting the flag rotated.

F: Flag Rotation

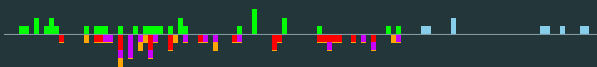
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- **Problem:** Count how many cells will change when painting the flag rotated.
- **Observation:** Since each column has to be repainted to one color, we will change $n - cnt_c$ cells in it (where c is the final color).

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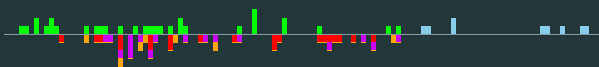
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- **Observation:** Since each column has to be repainted to one color, we will change $n - cnt_c$ cells in it (where c is the final color).
- **Solution:** Count how many cells won't change.

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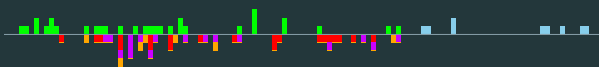
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 - First sort the array, then check for segments made of identical elements, this way we find the count of each cell color.

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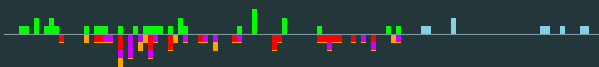
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 - $$\text{answer} = n^2 - \sum_c cnt_c^2$$

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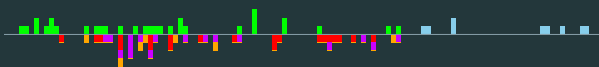
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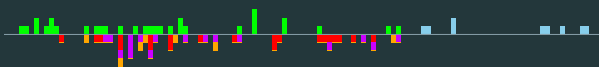
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- **Note:** this can also be done using a (hash) map.

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Statistics: 85 submissions, 31 accepted, 9 unknown

G: Galactic Expedition

Problem author: Veselin Mitev



- **Problem:** Navigate between wormholes to find the ancient relic, without running out of fuel.

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- **Problem:** Navigate between wormholes to find the ancient relic, without running out of fuel.
- **Observation:** You can refuel more than enough times to simply explore all wormholes, until you find a way to reach the relic.

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- **Observation:** You can refuel more than enough times to simply explore all wormholes, until you find a way to reach the relic.
- **Solution:** Perform a “live” search – explore the wormholes while always keeping enough fuel ($\frac{d}{2}$) to go back to home base:

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- **Solution:** Perform a “live” search – explore the wormholes while always keeping enough fuel ($\frac{d}{2}$) to go back to home base:
 - If you can reach the relic within the fuel limit, do that.

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- **Solution:** Perform a “live” search – explore the wormholes while always keeping enough fuel ($\frac{d}{2}$) to go back to home base:
 - If you can reach the relic within the fuel limit, do that.
 - Find the closest unexplored wormhole:
 - You can do that using **Dijkstra**, or **Floyd-Warshall**.

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 - Can we reach it while still having enough fuel to go back to home base?

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 - If yes: Go to that wormhole and update the distances between the points.

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- If we know all wormholes, it is guaranteed that we can reach the relic, if we follow an optimal path.

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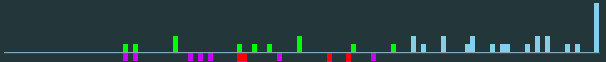
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Statistics: 3 submissions, 0 accepted, 3 unknown

H: Horrendous Mistake

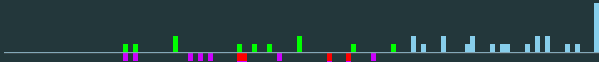
Problem author: Jeroen Op de Beek



- **Problem:** Calculate the value of the function `sum`, which uses values instead of indices.

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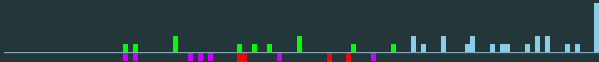
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- **Naive solution:** Simply run the function after every update. This takes $\mathcal{O}(n \cdot q)$ time, too slow!

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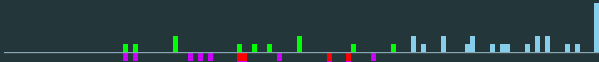
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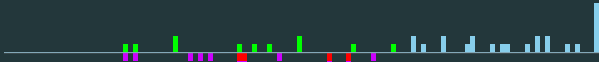
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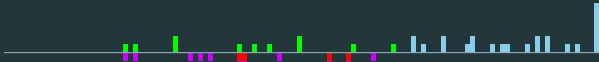
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- **Solution:** Do some extra bookkeeping:
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 - Calculate the value of `sum` for the initial array and store this.

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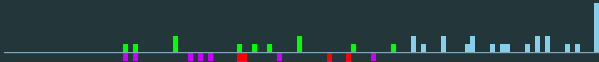
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- **Problem:** Calculate the value of the function `sum`, which uses values instead of indices.
- **Naive solution:** Simply run the function after every update. This takes $\mathcal{O}(n \cdot q)$ time, too slow!
- **Observation:** To be fast enough, every query must be processed in $\mathcal{O}(1)$.
- **Solution:** Do some extra bookkeeping:
 - Count how often every value occurs in the initial array ($= c_x$ for every $0 \leq x < n$).
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 - Update the value in the array.

H: Horrendous Mistake

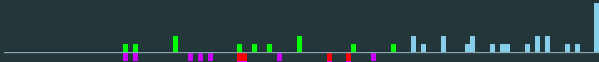
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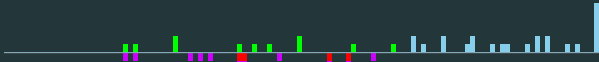
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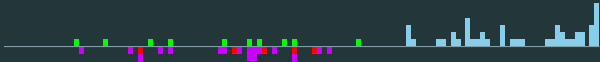


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Statistics: 46 submissions, 11 accepted, 24 unknown

I: Intelligence Exploration

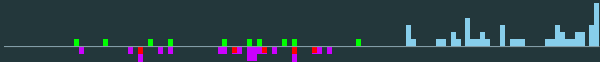
Problem author: Makar Kuleshov



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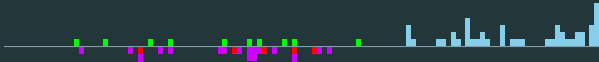
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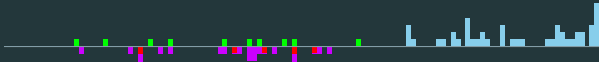
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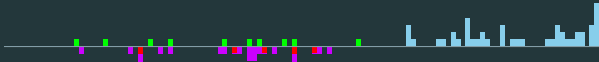


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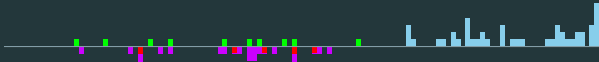


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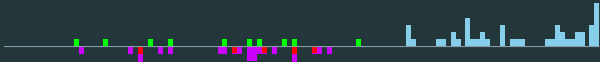


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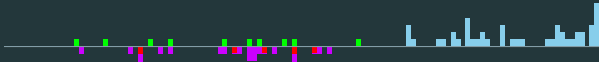


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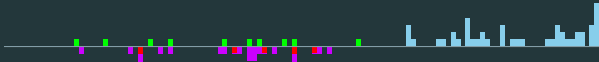
$$a_l \rightarrow \dots \rightarrow 1 \rightarrow \underbrace{0 \rightarrow \dots \rightarrow 0}_{k \text{ zeros}}$$

If k is even then the result equals 1.

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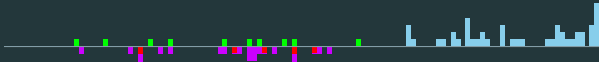
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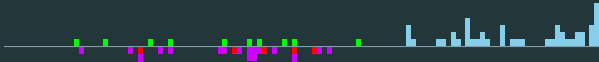
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Statistics: 78 submissions, 10 accepted, 46 unknown

J: Jailbreak

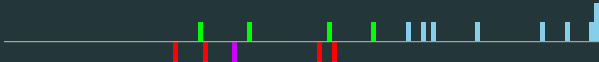
Problem author: Wietze Koops



- **Problem:** Escape from a $w \times h$ grid jail where you can go up only if you have a ladder. Ladders can be carried to a different place on the same storey.

J: Jailbreak

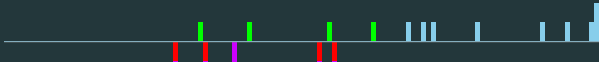
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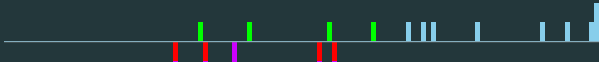
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 - Using a for loop in both directions, determine which cells can access a ladder.

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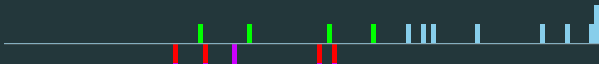
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Statistics: 18 submissions, 4 accepted, 9 unknown

K: Kangaroo Race

Problem author: Leon van der Waal



- **Problem:** A kangaroo jumps from x to $x + x(x - 1) = x^2$ in one step. How many steps until it reaches 1?

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- So after i jumps, the kangaroo is in segment $x^{2^i} \bmod n$.

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- Notice that when a kangaroo jumps over the n -th segment, it jumps to $x^2 \bmod n$.
- So after i jumps, the kangaroo is in segment $x^{2^i} \bmod n$.
- Therefore we need to determine the first i such that $x^{2^i} \equiv 1 \bmod n$.

K: Kangaroo Race

Problem author: Leon van der Waal



- **Problem:** Determine the first i such that $x^{2^i} \equiv 1 \pmod n$.

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- **Problem:** Determine the first i such that $x^{2^i} \equiv 1 \pmod n$.
- **Observation:** If $\gcd(x, n) \neq 1$, then $\gcd(x, n) \mid x^{2^i} \pmod n$, so the kangaroo will never reach 1.

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- Otherwise, $x^r \equiv 1 \pmod n$ for some r . We call the smallest such r the *order* of $x \pmod n$.

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- Otherwise, $x^r \equiv 1 \pmod n$ for some r . We call the smallest such r the *order* of $x \pmod n$.
- Notice that the powers of x repeat every r -th power:

$$1, x, x^2, x^3, \dots, x^{r-1}, x^r = 1, x^{r+1} = x, x^{r+2} = x^2, x^{r+3} = x^3, \dots$$

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- **Problem:** What is the first i such that $x^{2^i} \equiv 1 \pmod{n}$.
- Therefore, any i that satisfies $x^{2^i} \equiv 1 \pmod{n}$ also satisfies $2^i \equiv 0 \pmod{r}$.

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- **Observation:** $r \leq n$, so $k \leq \log_2(n)$

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- **Solution:** It therefore suffices to check the first $\log_2(n) < 60$ jumps. If the kangaroo has not reached segment 1 by then, it never will.

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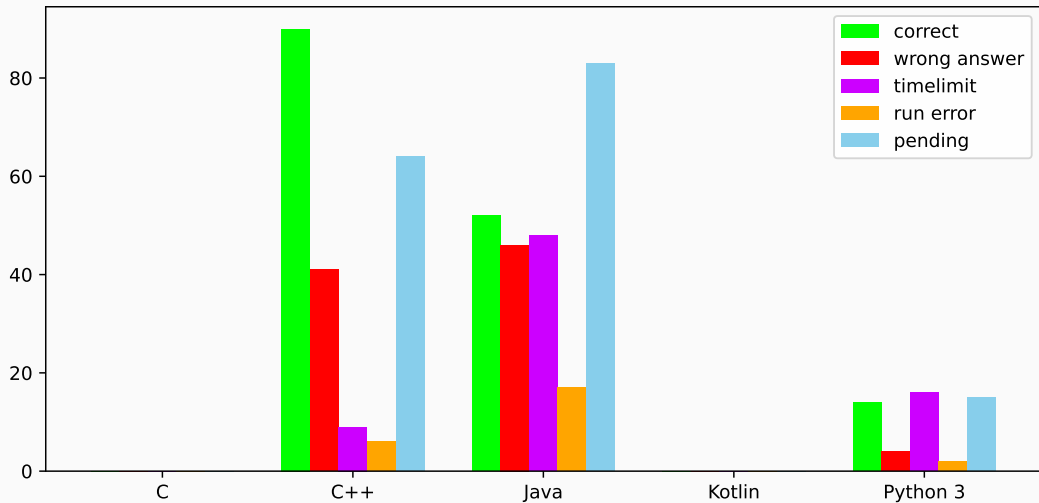
Statistics: 44 submissions, 2 accepted, 27 unknown

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

<https://fpcs2024.bapc.eu/>

Friday 10 May 2024 13:00–17:00

Language stats



Jury work

- 447 commits (last year: 361)

¹After codegolfing

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- 447 commits (last year: 361)
- 357 secret test cases (last year: 339)

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Random facts

Jury work

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- 120 accepted jury/proofreader solutions (last year: 96)

¹After codegolfing

Jury work

- 447 commits (last year: 361)
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- 120 accepted jury/proofreader solutions (last year: 96)
- The minimum¹ number of lines the jury needed to solve all problems is

$$2 + 1 + 11 + 1 + 5 + 1 + 22 + 5 + 3 + 11 + 4 = 66$$

On average 6.0 lines per problem, down from 6.4 last year

¹After codegolfing

Thanks to the proofreaders:

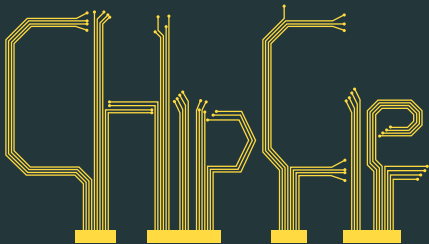
- Arnoud van der Leer (TU Delft)
- Daniel Cortild (RU Groningen)
- Davina van Meer (Delft)
- Henk van der Laan (TU Eindhoven)
- Matei Tinca (VU Amsterdam, 📍)
- Michael Vasseur
(VU Amsterdam / DOMjudge)
- Mylène Martodihardjo (VU Amsterdam)
- Nicky Gerritsen
(TU Eindhoven / DOMjudge)
- Pavel Kunyavskiy
(JetBrains Amsterdam, 📍 Kotlin Hero 📍)
- Ragnar Groot Koerkamp
(ETH Zürich / NWERC jury)
- Rick Wouters (TU Eindhoven)
- Sièna van Schaick (Radboud Nijmegen)
- Thomas Verwoerd
(TU Delft, 📍 Kotlin Hero 📍)
- Yoshi van den Akker (TU Delft)

Thanks to the Jury for the Freshmen Programming Contests:

- Angel Karchev (TU Delft)
- Ivan Bliznets (RU Groningen)
- Jeroen Op de Beek (TU Delft)
- Leon van der Waal (TU Delft)
- Maarten Sijm (TU Delft)
- Maciek Sidor (VU Amsterdam)
- Makar Kuleshov (TU Delft)
- Mansur Nurmukhambetov (RU Groningen)
- Tymon Cichocki (TU Delft)
- Veselin Mitev (TU Delft)
- Vitor Greati (RU Groningen)
- Wietze Koops (Radboud Nijmegen / RU Groningen)
- Wiktor Cupiał (TU Delft)



Want to help out with future contests?



<https://wisv.ch/chipcie-interest>

<https://wisv.ch/runner>