# Freshmen Programming Contests 2024

Solutions presentation

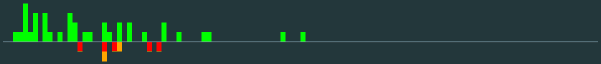
By the Freshmen Programming Contests 2024 jury for:

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

May 4, 2024

# D: Dragged-out Duel

**Problem author: Wietze Koops**



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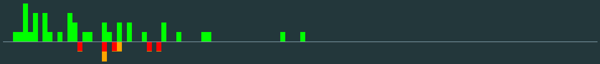

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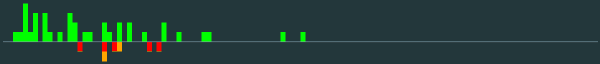

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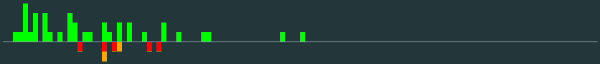

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Statistics: 45 submissions, 37 accepted

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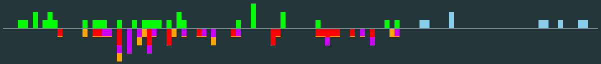
Statistics: 75 submissions, 36 accepted, 1 unknown

# F: Flag Rotation

Problem author: Jeroen Op de Beek



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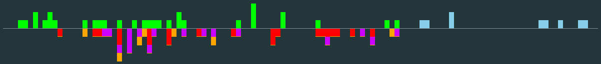

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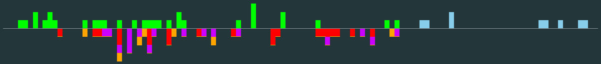

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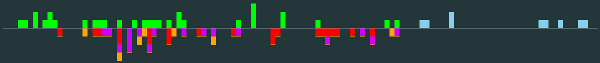

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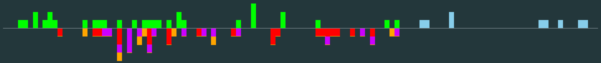

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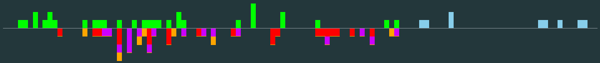

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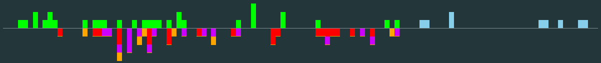

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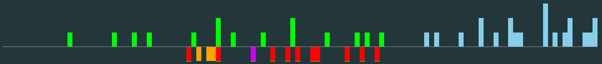
Statistics: 85 submissions, 31 accepted, 9 unknown

# E: European Election

Problem author: Veselin Mitev



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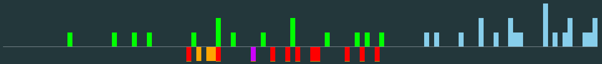

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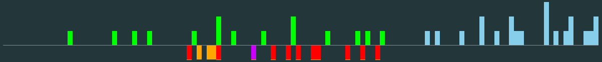

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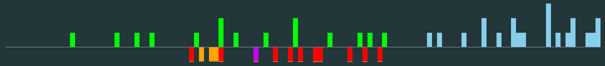

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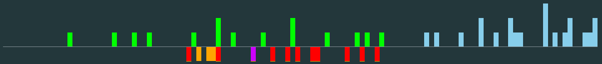

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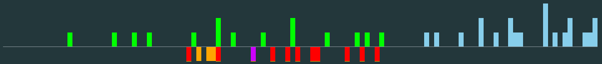

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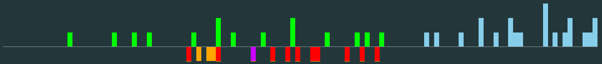

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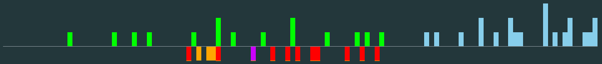

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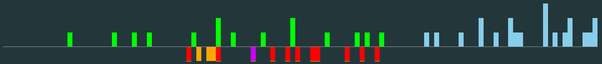

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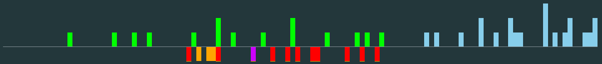

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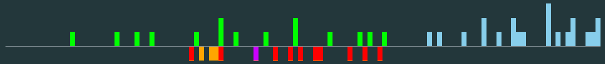

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Statistics: 50 submissions, 15 accepted, 21 unknown

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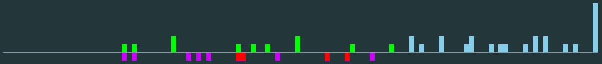

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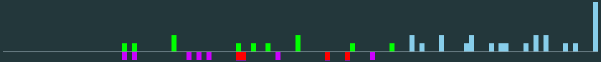

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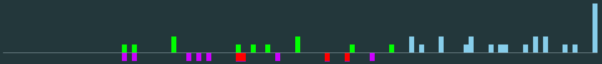

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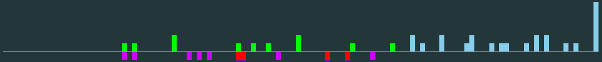

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- **Observation:** To be fast enough, every query must be processed in $\mathcal{O}(1)$.
- **Solution:** Do some extra bookkeeping:
  - Count how often every value occurs in the initial array ($= c_x$ for every $0 \leq x < n$).

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Problem author: Jeroen Op de Beek

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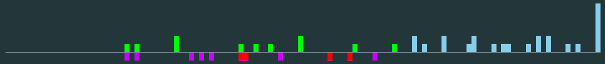

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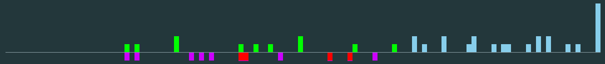

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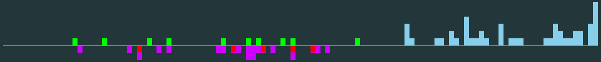
Statistics: 46 submissions, 11 accepted, 24 unknown

# I: Intelligence Exploration

**Problem author: Makar Kuleshov**



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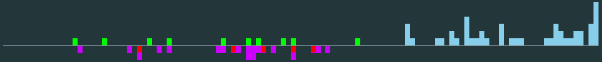

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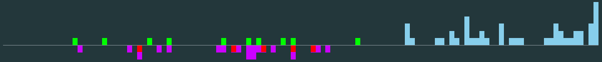

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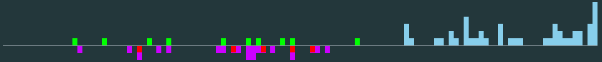

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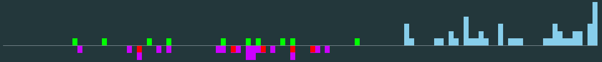

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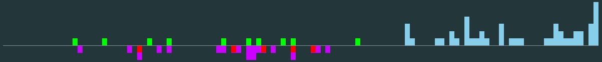

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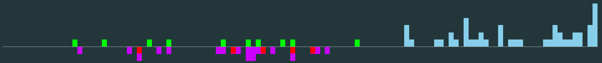

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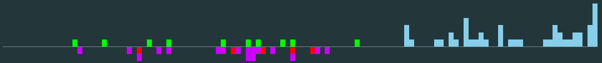

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Statistics: 78 submissions, 10 accepted, 46 unknown

# A: Annoying Alliterations

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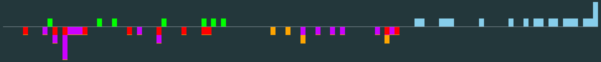

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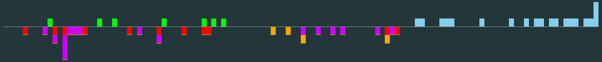

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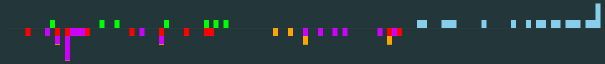

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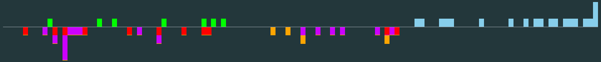

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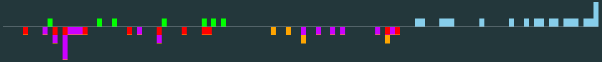

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- Similarly, $|p(v, t)| > |p(s, t)|$, but these two together give us a contradiction. $\square$

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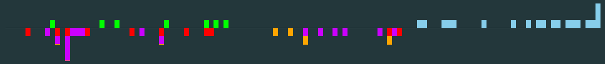

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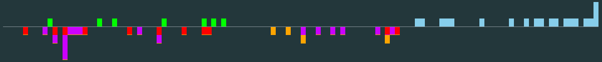

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Statistics: 58 submissions, 7 accepted, 20 unknown

# 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.

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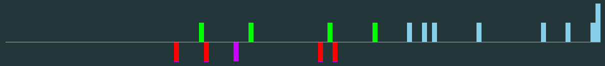

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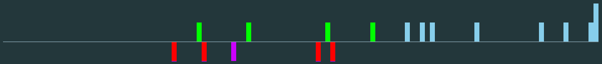

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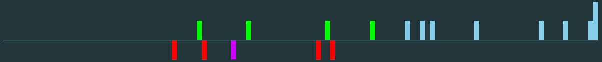

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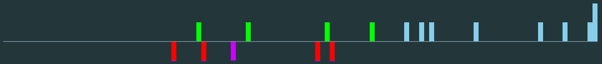
- **Solution:**
  - Using a for loop in both directions, determine which cells can access a ladder.
  - Then we know for each cell to which cell we can move.
  - Hence, we can define a graph representing the grid.

# 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.
- **Observation:** If we know to which holes a ladder can be carried, then for each cell, we know which cell we can move to.
- **Solution:**
  - Using a for loop in both directions, determine which cells can access a ladder.
  - Then we know for each cell to which cell we can move.
  - Hence, we can define a graph representing the grid.
  - Determining whether a path exists from the starting cell to an exit can be done using $\mathcal{O}(wh)$ BFS/DFS.

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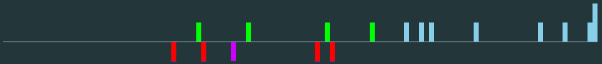

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Statistics: 18 submissions, 4 accepted, 9 unknown

# C: Curious Jury

Problem author: Jeroen Op de Beek

- **Problem:** Given two types of penalty times for $n$ teams ($1 \leq l_i < s_i \leq n$), find out over all ways of choosing the type of penalty time for each team, how many fixed points the scoreboard contains in total.

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- **Observation 3:** Other teams form 3 groups:
  - **A** Teams with $l_j < f, s_j < f$
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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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- Can precalculate factorial[$k$] and twopower[$k$] in $\mathcal{O}(n)$.
- Can find inverse of factorial[$n$] in $\mathcal{O}(\log(MOD))$ (or if you don't know how to calculate a modular inverse, you can bruteforce it on your own computer).

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- Now fill the array invfactorial[$k$] using invfactorial[$k$] $=$ invfactorial[$k+1$] $\cdot (k+1)$ in $\mathcal{O}(n)$.

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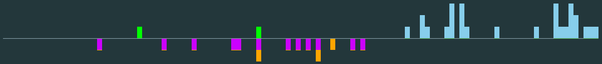
Statistics: 6 submissions, 3 accepted, 2 unknown

# K: Kangaroo Race

Problem author: Leon van der Waal



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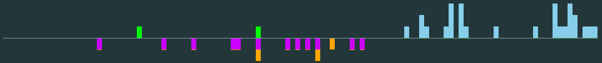

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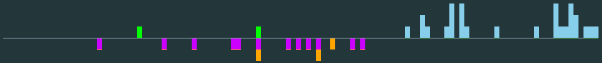

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- So after $i$ jumps, the kangeroo is in segment $x^{2^i} \mod n$.

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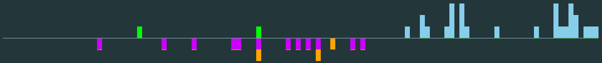

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- Notice that when a kangeroo jumps over the $n$-th segment, it jumps to $x^2 \mod n$.
- So after $i$ jumps, the kangeroo is in segment $x^{2^i} \mod n$.
- Therefore we need to determine the first $i$ such that $x^{2^i} \equiv 1 \mod n$.

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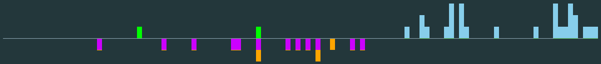

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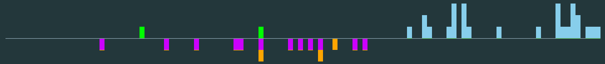

- **Problem:** Determine the first $i$ such that $x^{2^i} \equiv 1 \mod n$.
- **Observation:** If $\gcd(x, n) \neq 1$, then $\gcd(x, n) \mid x^{2^i} \mod n$, so the kangeroo will never reach 1.

- **Problem:** Determine the first $i$ such that $x^{2^i} \equiv 1 \mod n$.
- **Observation:** If $\gcd(x, n) \neq 1$, then $\gcd(x, n) \mid x^{2^i} \mod n$, so the kangeroo will never reach 1.
- Otherwise, $x^r \equiv 1 \mod n$ for some $r$. We call the smallest such $r$ the *order* of $x$ mod $n$.

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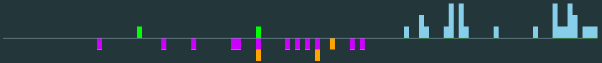

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- Otherwise, $x^r \equiv 1 \mod n$ for some $r$. We call the smallest such $r$ the *order* of $x$ mod $n$.
- Notice that the powers of $x$ repeat every $r$-th power:

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

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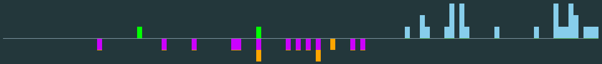

- **Problem:** What is the first $i$ such that $x^{2^i} \equiv 1 \mod n$.
- Therefore, any $i$ that satisfies $x^{2^i} \equiv 1 \mod n$ also satisfies $2^i \equiv 0 \mod r$.

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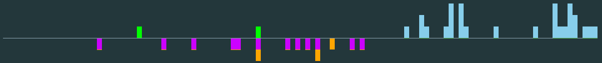

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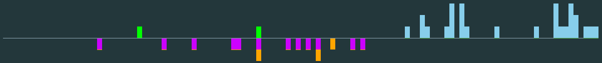

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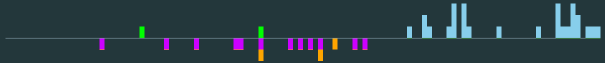

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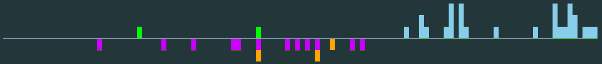

- **Problem:** What is the first $i$ such that $x^{2^i} \equiv 1 \mod n$.
- **Observation:** $r \leq n$, so $k \leq \log_2(n)$
- **Solution:** It therefore suffices to check the first $\log_2(n) < 60$ jumps. If the kangeroo has not reached segment 1 by then, it never will.

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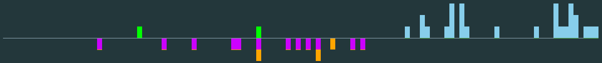

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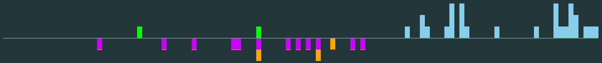

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Statistics: 44 submissions, 2 accepted, 27 unknown

# G: Galactic Expedition

**Problem author: Veselin Mitev**

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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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- **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:
  - 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**.

# G: Galactic Expedition

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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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- If we know all wormholes, it is guaranteed that we can reach the relic, if we follow an optimal path.
- **Time Complexity:** $\mathcal{O}(n^3)$ or $\mathcal{O}(n^3 \log n)$. Or if you're clever about how you cache the results from the Dijkstra search algorithm you can do it in $\mathcal{O}(n^2)$ or $\mathcal{O}(n^2 \log n)$.

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Statistics: 3 submissions, 0 accepted, 3 unknown

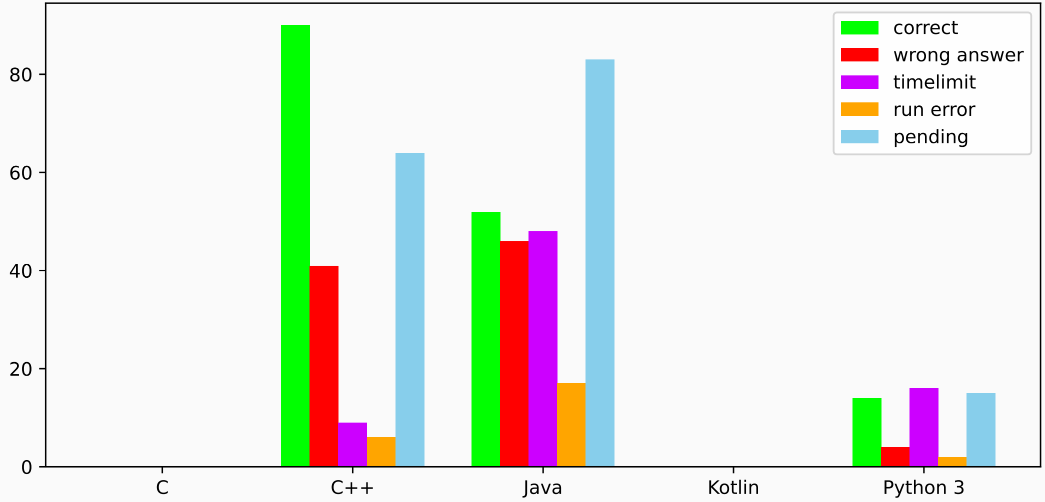
# Open online contest

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



# Random facts

## Jury work

- 448 commits (last year: 361)

[1] *After* codegolfing

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# Random facts

## Jury work

- 448 commits (last year: 361)
- 357 secret test cases (last year: 339)
- 120 accepted jury/proofreader solutions (last year: 96)
- The minimum[1] 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

[1] *After* codegolfing

## Thanks to the proofreaders:

- Arnoud van der Leer (TU Delft)
- Daniel Cortild (RU Groningen)
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- Henk van der Laan (TU Eindhoven)
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- 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)
- Siëna van Schaick (Radboud Nijmegen)
- Thomas Verwoerd
  (TU Delft, Kotlin Hero 🎈)
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- 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