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

- **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.

A: Annoying Alliterations

Problem Author: Maciek Sidor

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- **Naive solution:** Check every pair. Runs in $\mathcal{O}(n^2)$, too slow.

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- **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.
- **Naive solution:** Check every pair. Runs in $\mathcal{O}(n^2)$, too slow.
- **Claim:** For a given pair s, t and a third word v such that $|v| \geq \max(|s|, |t|)$, we can always replace one of the words and the score will not decrease.

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

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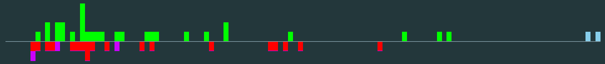
Statistics: 23 submissions, 1 accepted, 6 unknown

B: Building Pyramids

Problem Author: Maarten Sijm



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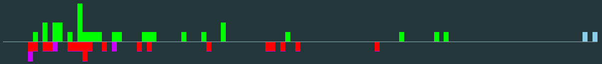

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- **Observation:** The pyramid consists of n equilateral triangles.
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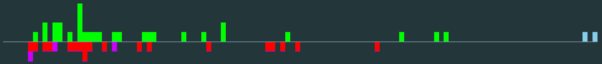

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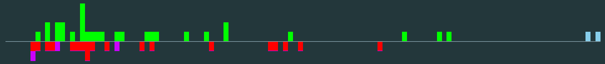

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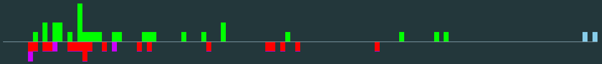

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- **Pitfall:** If t is an `int`, $t \cdot (t+1)$ overflows. Use 64-bit integers!

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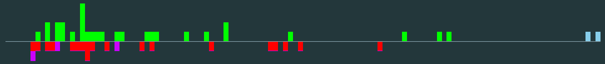

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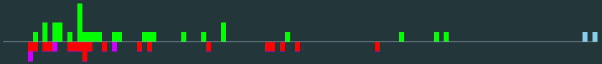

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Statistics: 53 submissions, 29 accepted, 2 unknown

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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- **Observation 4:** The number of ways to choose the other submission times, for team i to have a fixed point at rank f: $2^{|A|+|C|} \cdot \binom{|B|}{f-|A|}$
- Need to calculate $\mathcal{O}(n)$ binomial coefficients $\binom{a}{b}$, with $0 \leq a, b \leq n$: $\binom{a}{b} = \frac{a!}{b!(a-b)!}$ and 2^a for $0 \leq a \leq n$, both $\mod (10^9 + 7)$

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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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- 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.

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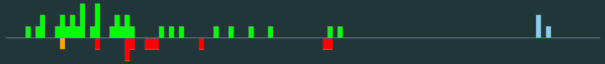
Statistics: 3 submissions, 0 accepted, 3 unknown

D: Dragged-out Duel

Problem Author: Wietze Koops



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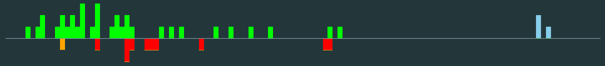

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- **Solution:**
  - Read the two lines character by character, increment a counter if player 1 wins and decrement it if player 2 wins.
  - Finally, print “`victory`” if the counter is positive, and “`defeat`” if it is negative.

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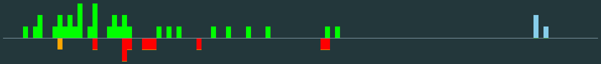

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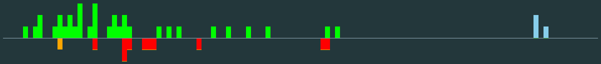
  - Read the two lines character by character, increment a counter if player 1 wins and decrement it if player 2 wins.
  - Finally, print "`victory`" if the counter is positive, and "`defeat`" if it is negative.
- **Complexity:** $\mathcal{O}(n)$.

D: Dragged-out Duel

Problem Author: Wietze Koops



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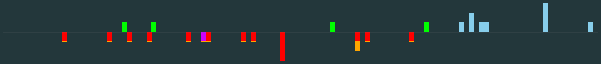
- **Complexity:** $\mathcal{O}(n)$.

Statistics: 50 submissions, 34 accepted, 3 unknown

E: European Election

Problem Author: Veselin Mitev



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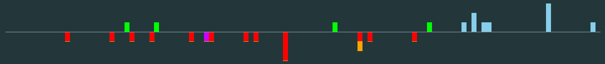
E: European Election

Problem Author: Veselin Mitev



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E: European Election

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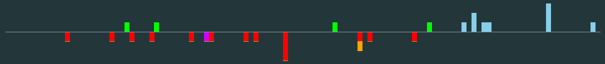

- **Problem:** Given ranked-choice ballots, determine the candidate who beats all other candidates.
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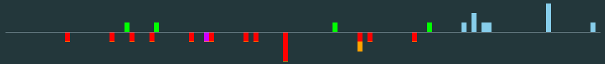
E: European Election

Problem Author: Veselin Mitev



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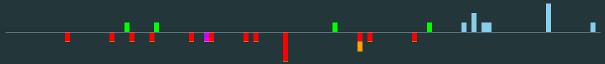

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- **Solution:**
  - Pick a candidate d.

E: European Election

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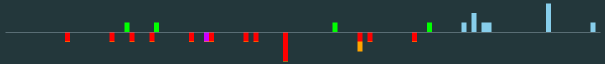

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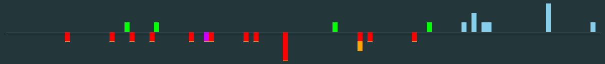

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  - Check if d beats all other candidates. Runs in $\mathcal{O}(n \cdot k)$.

E: European Election

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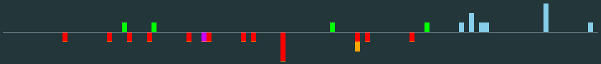

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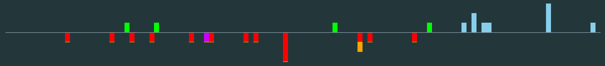

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- **Complexity:** $\mathcal{O}(n \cdot k)$.
  - But we chose the time limit to also accept $\mathcal{O}(n \cdot k^2)$ or even $\mathcal{O}(n \cdot k^3)$.

E: European Election

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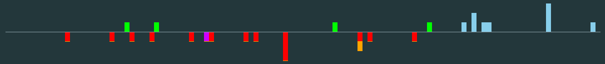

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Statistics: 29 submissions, 4 accepted, 9 unknown

F: Flag Rotation

Problem Author: Jeroen Op de Beek

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

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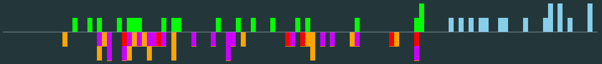

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  - First sort the array, then check for segments made of identical elements, this way we find the count of each cell color.
  - answer $= n^2 - \sum_c cnt_c^2$

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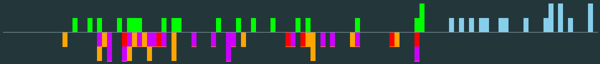

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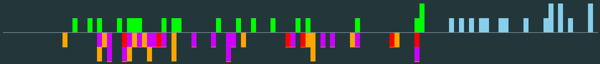

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- **Complexity:** $\mathcal{O}(n \log n)$.
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Statistics: 76 submissions, 20 accepted, 16 unknown

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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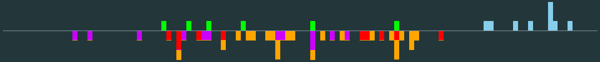
Statistics: 0 submissions, 0 accepted

H: Horrendous Mistake

Problem Author: Jeroen Op de Beek



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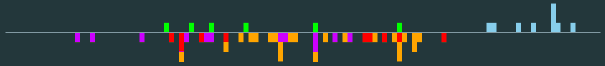

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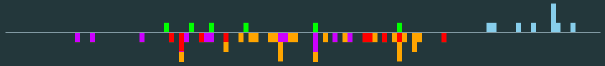

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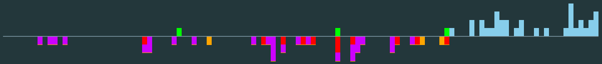
Statistics: 59 submissions, 6 accepted, 9 unknown

I: Intelligence Exploration

Problem Author: Makar Kuleshov



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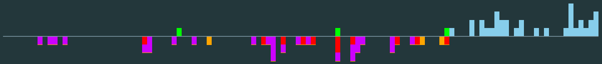

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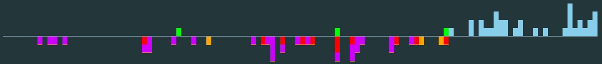

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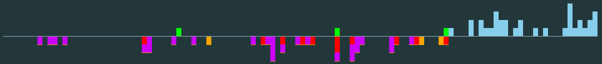

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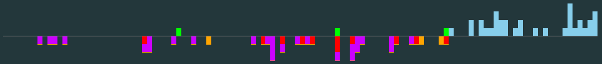

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Statistics: 76 submissions, 3 accepted, 33 unknown

J: Jailbreak

Problem Author: Wietze Koops

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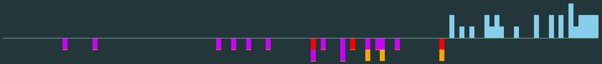
Statistics: 18 submissions, 0 accepted, 16 unknown

K: Kangaroo Race

Problem Author: Leon van der Waal



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- 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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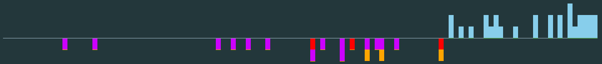

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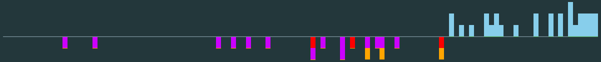

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- Notice that the powers of x repeat every r-th power:

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

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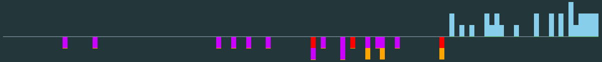

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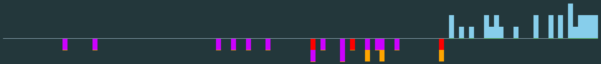

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Statistics: 49 submissions, 0 accepted, 29 unknown

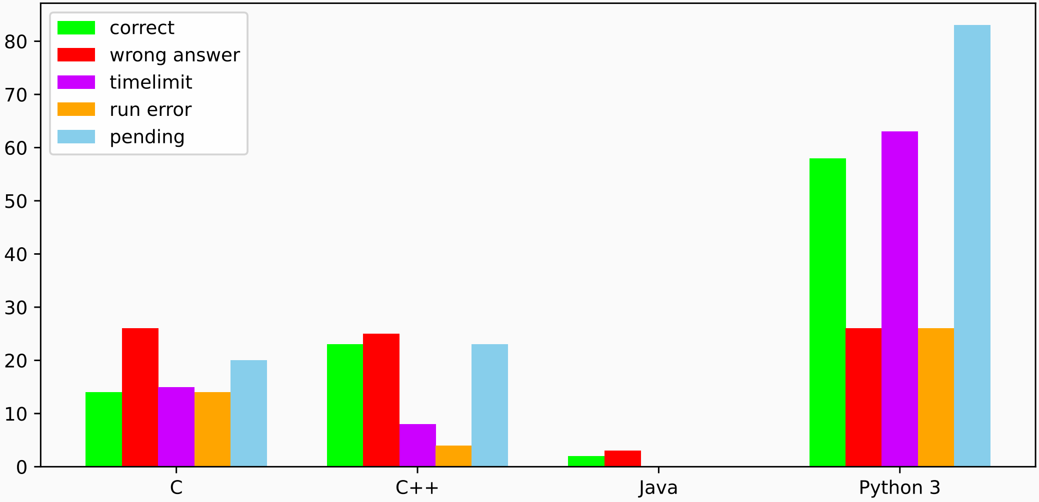
Open online contest

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

- 447 commits (last year: 361)

[1] *After* codegolfing

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- 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)
- 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)

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- 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)