2025 NWERC

NWERC 2025

Solutions presentation

November 30, 2025

KIT Karlsruhe Institute of Technology

CPUlm

icpc International Collegiate Programming Contest

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- **Reinier Schmiermann**
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- **Vitaly Aksenov**
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- **Wendy Yi**
  Karlsruhe Institute of Technology
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  Karlsruhe Institute of Technology

Big thanks to our proofreaders and test solvers

- **Andreas Grigorjew**
  Paris Dauphine University - PSL
- **Arne Alex**
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- **Pavel Kunyavskiy**
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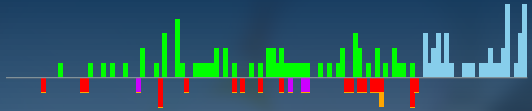
- **Vlad Ulmeanu**
  Politehnica University of Bucharest

A: Arcade Crane

Vitaly Aksenov

Problem

Given an unsorted sequence of the numbers $1, \ldots, n$, sort it using operations of the following kind: cut three consecutive values from the sequence and paste them somewhere else.



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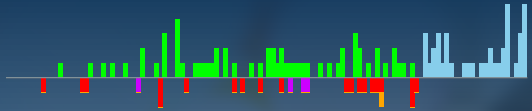
- While there are more than 5 numbers, locate the largest one and move it to the back.
- This can be achieved in at most 2 steps and reduces the problem size by 1.
- For the last 5 numbers, either:
  - perform some graph search through the remaining $5! = 120$ permutations; or
  - just do random steps until the sequence is sorted.
- Total number of steps $\lesssim 2n + 160$



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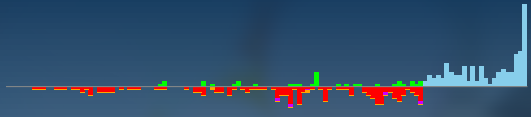
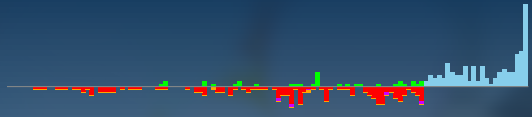


B: Bisecting Bargain

Wendy Yi, Michael Zündorf

Problem

You want to withdraw €n ($1 \leq n \leq 10\,000$) from a cash machine. It can dispense cash in the form of $1, 2, 5, 10, 20, 50, 100, 200, 500$ (in euros). Check if the machine can dispense cash adding up to €n which cannot be split evenly into two piles of €$n/2$.



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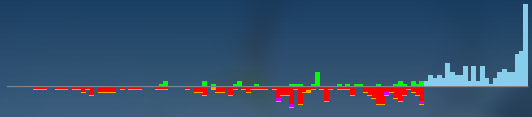
Naive solution (Subset Sum DP + Bruteforce)

Given a division into coins and notes summing to €n, classic subset sum dynamic programming can be used to check splittability:

$$DP[\text{considering notes up to position } i][\text{sum of cash so far}] = \text{can choose subset with this sum}$$

Because this DP uses True / False values, it can be sped up using bitsets, to achieve a complexity of $\mathcal{O}(\#\text{ notes}\,\frac{n}{w})$, where w is the wordsize, typically 32 or 64.



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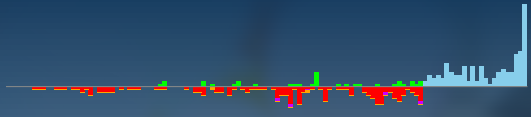
Try out all possible splittings into all the different coins and notes, and check using the knapsack DP. This is too slow.



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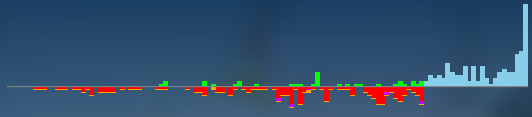
Silly solution

Optimize the bruteforce as much as possible, using heuristics, and precompute all the answers on your own machine.
Then submit a big file which stores all possible answers up to 10 000 in it.



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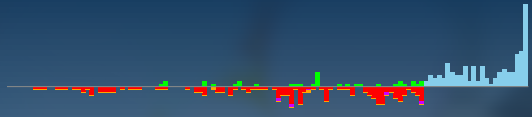
Observations

- For €1, €5, €10, €50 and €100, using 2 or more of the same coin or note is unnecessary. For example, switching €10 $\times$ 2 $\implies$ €20 is strictly better.



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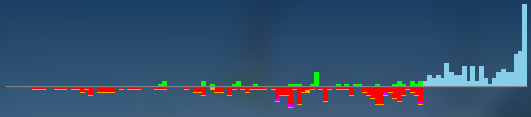
  For example, switching €10 $\times$ 2 $\implies$ €20 is strictly better.
- For €2 and €20, using 5 or more of the same coin or note is unnecessary.
  Switching €2 $\times$ 5 $\implies$ €10 is also strictly better.



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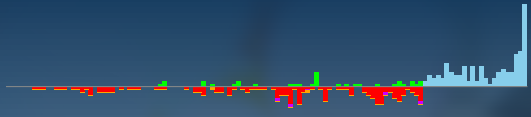
- For €2 and €20, using 5 or more of the same coin or note is unnecessary. Switching €2 $\times$ 5 $\implies$ €10 is also strictly better.

Easy solution

Run the bruteforce, but use the above observations to reduce the number of options to check.
A rough upper bound for the number of options is $2^5 5^2 (10\,000/500) = 16\,000$, but in reality way less options actually sum to n. Here we bruteforce how many of the lower denominations we choose, also bruteforce the number of €500 notes.



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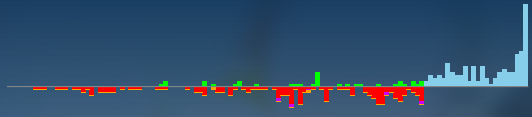
Greedy solution

It is almost possible to solve this problem greedily, but there are tricky corner cases. This is left as an exercise to the reader.



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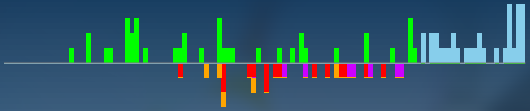
Statistics: 322 submissions, 33 accepted, 141 unknown



C: Canal Crossing

Michael Zündorf

Problem

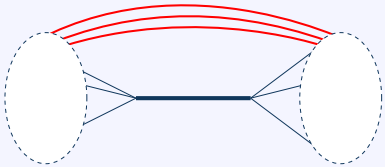
Given a tree and a set of extra edges (bridges), find the shortest tour through the extra edges, that uses each tree-edge at most once.

C: Canal Crossing

Michael Zündorf

Solution

- Each tree edge connects two parts of the graph.



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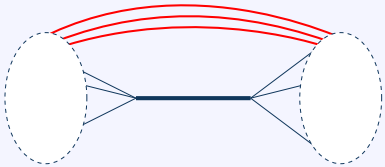
Solution

- Each tree edge connects two parts of the graph.
- If an odd number of bridges connect the two parts, the tree edge must be used in the optimal tour.



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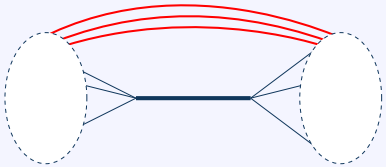
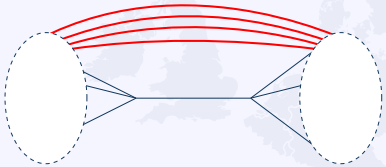
- Each tree edge connects two parts of the graph.
- If an odd number of bridges connect the two parts, the tree edge must be used in the optimal tour.
- The inverse is also true, if the number is even, the tree edge is not used in the shortest solution.





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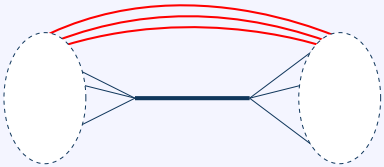
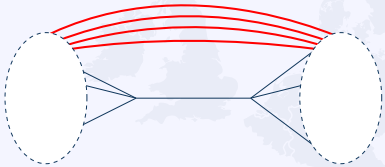
- Starting with leaves, count amount of bridges connected to that sub tree. Only the parity of this number matters.





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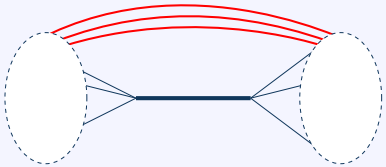

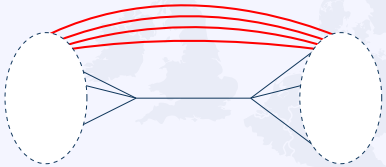

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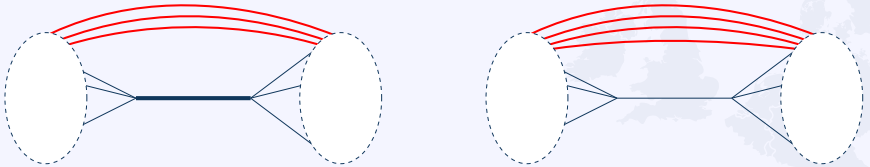

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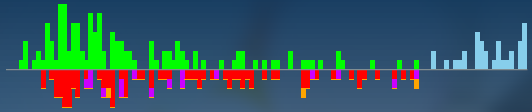

D: Dreamcatcher

Christopher Weyand

Problem

Wrap yarn around a wheel with n notches, by taking steps of k notches each time.
Given n, what value of k maximizes the amount of yarn used?

D: Dreamcatcher

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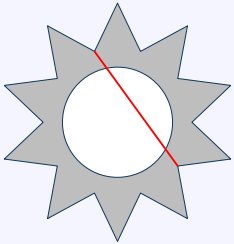
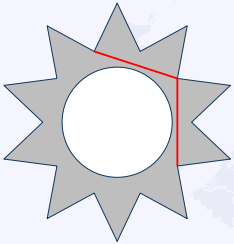
Observations

- If $\gcd(k, n) > 1$, then replacing k by $\frac{k}{\gcd(k,n)}$ increases the length.





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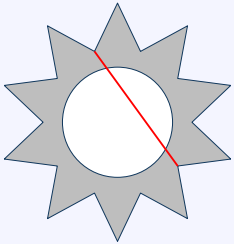
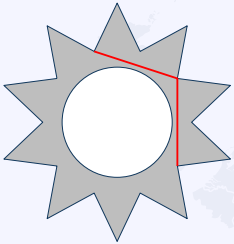
- If $\gcd(k, n) > 1$, then replacing k by $\frac{k}{\gcd(k,n)}$ increases the length.
- If $\gcd(k, n) = 1$, then the total length is $n \cdot$ (length of single chord), which is maximized when k is as close to $\frac{n}{2}$ as possible.





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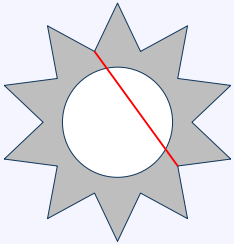
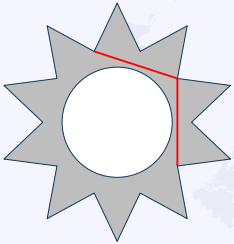
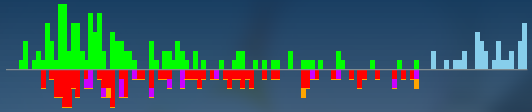
- Need to find k coprime with n which is as close to $\frac{n}{2}$ as possible.







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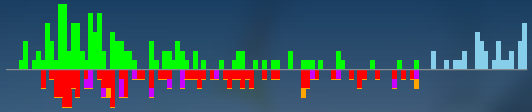

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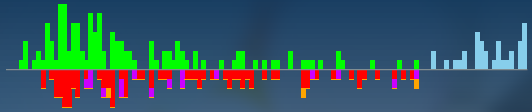

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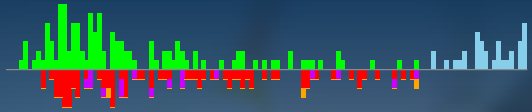
- Can use linear search, starting from $\frac{n}{2}$.
- Alternatively, use a direct formula:
  - if $n \equiv 1 \mod 2$, take $k = \frac{n-1}{2}$,
  - if $n \equiv 2 \mod 4$, take $k = \frac{n}{2} - 2$,
  - if $n \equiv 0 \mod 4$, take $k = \frac{n}{2} - 1$.



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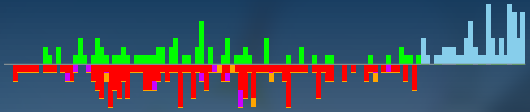
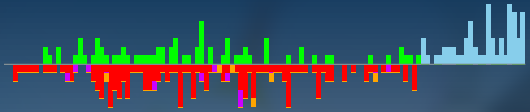


E: Erratic Lights

Atli Fannar Franklín

Problem

Every time you touch one of the $n \leq 100$ light bulbs, it randomly selects a new colour (red/green/blue), each with equal probability. What is the expected number of times you need to touch a light bulb to make all of them have the same colour?



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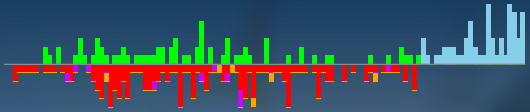
The easy cases

- If all lights are equal, output 0.



E: Erratic Lights

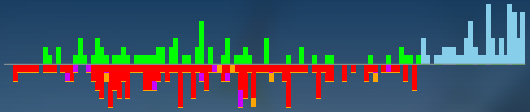
Atli Fannar Franklín

Problem

Every time you touch one of the $n \leq 100$ light bulbs, it randomly selects a new colour (red/green/blue), each with equal probability. What is the expected number of times you need to touch a light bulb to make all of them have the same colour?

The easy cases

- If all lights are equal, output 0.
- If there are only two different colours initially, change the least-occurring colours to the most-occurring ones. This takes expected $3x$ touches (where x is the initial count of the least-occurring colour).



E: Erratic Lights

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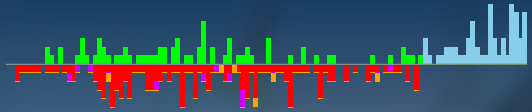
Solution for three different colours

Say the number of occurrences of each colour are $a \leq b \leq c$.

- Change the coloured light with the fewest occurrences to one of the other two. Disregarding which colour they change into, this takes expected $\frac{3}{2}a$ touches.



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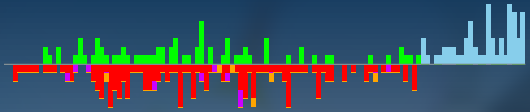

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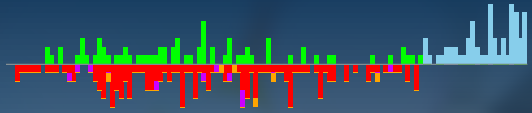
- Only the *number* of lights in each colour is relevant, so we combine them. Say that i of the a lights turned into colour b, this happens $\binom{a}{i}$ times. Change the minimum of the two remaining colours to the final colour, this takes expected 3 touches each.



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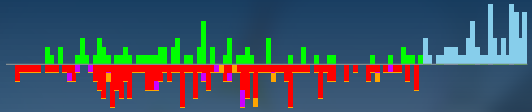
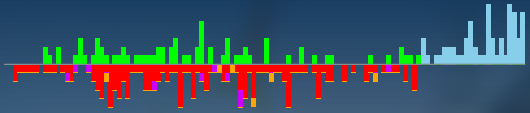
- Only the *number* of lights in each colour is relevant, so we combine them. Say that i of the a lights turned into colour b, this happens $\binom{a}{i}$ times. Change the minimum of the two remaining colours to the final colour, this takes expected 3 touches each.
- The final expected number of touches is:

$$\tfrac{3}{2}a + \frac{1}{2^a}\sum_{i=0}^{a}\binom{a}{i}3\min(b+i, c+(a-i))$$



Alternative solutions

- Dynamic Programming, anything up to $\mathcal{O}(n^3)$ will pass.



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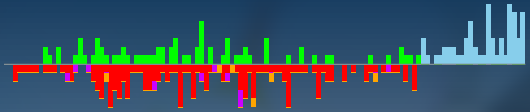

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Statistics: 286 submissions, 72 accepted, 63 unknown

F: Fair Share

Yidi Zang

Problem

- There are n people who each have a_i cash and a bill of b_i.
- Choose a person i which does not pay more than b_i if they pay the bill and get all cash from others.

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- There are n people who each have a_i cash and a bill of b_i.
- Choose a person i which does not pay more than b_i if they pay the bill and get all cash from others.

Observation

- The ith person can pay, if: $(\sum_{j=1}^{n} b_j) - (\sum_{j=1}^{n} a_j) + a_i \leq b_i$.
- This is equivalent to: $(\sum_{j=1}^{n} b_j) - (\sum_{j=1}^{n} a_j) \leq b_i - a_i$

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Solution

- Precompute $S = (\sum_{j=1}^{n} b_j) - (\sum_{j=1}^{n} a_j)$.
- For each i check whether $S \leq b_i - a_i$.
- Runtime: $\mathcal{O}(n)$.

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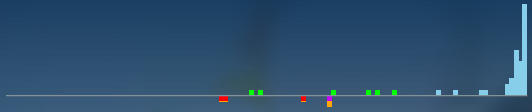
Statistics: 169 submissions, 138 accepted

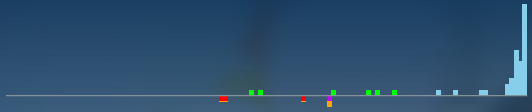


G: Group Photo

Lucas Schwebler

Problem

Given a permutation, reorder as few elements as possible to make it mountain-shaped (first increasing then decreasing) in $\mathcal{O}(n \log n)$.



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Given a permutation, reorder as few elements as possible to make it mountain-shaped (first increasing then decreasing) in $\mathcal{O}(n \log n)$.

First insight

If we place elements from smallest to largest, each element will go to one of the borders.
This leads to a quadratic DP with state space

(Num elements placed on the left so far, Num elements placed on the right so far).

Transition value is 0 if element is misplaced, and 1 if it stays where it is.

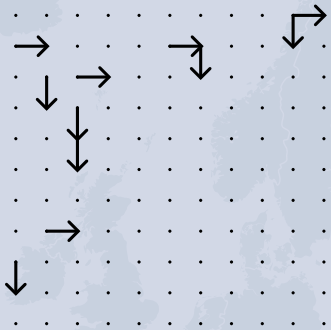
G: Group Photo

Lucas Schwebler

Visualizing the DP state space

Need to find path from top left to bottom right that

- only moves down and right, and
- hits as many arrows as possible.



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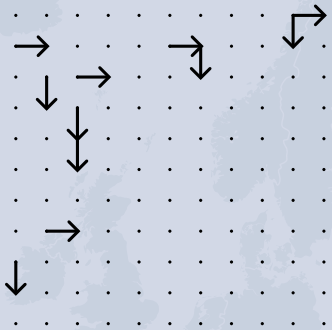
Key insight: there are at most $2n$ arrows!



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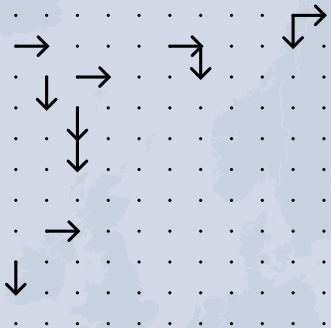
Possible approaches:

- Rephrase DP as Longest Increasing Subsequence.
- Quickly simulate DP using segment tree or ordered set.



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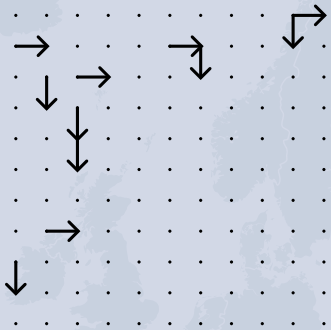
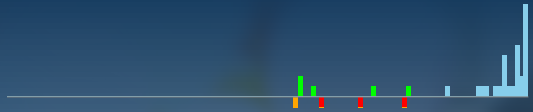


Statistics: 50 submissions, 6 accepted, 39 unknown

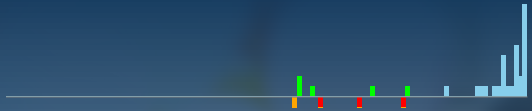


H: Hasty Haul

Michael Zündorf

Problem

Find an implicit matching on the set of n bit binary strings with k ones, or report that no such matching exists. Two binary strings are adjacent if one can be transformed into the other by swapping the values at two distinct indices.



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Impossible case

A matching does not exist if the number of states is odd, i.e. $\binom{n}{k} = 1 \pmod 2$. In all other cases a matching can be created.

H: Hasty Haul

Michael Zündorf

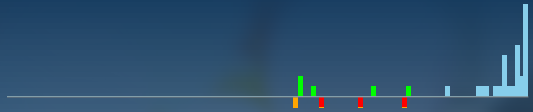
Construction

There are many solutions. One is to find a Hamiltonian path, then match the i-th value to the $(i \oplus 1)$-th.

- Build the Hamiltonian path $H(n, k)$ recursively.
- $H(n, k) = 0H(n-1, k) + 1H^R(n-1, k-1)$ where H^R is the reversed Hamiltonian path.

0	00001111
	$\cdots$ $H(n-1, k)$
0	10000111

1	10000011
	$\cdots$ $H^R(n-1, k-1)$
1	00000111



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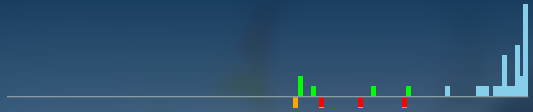
Runtime

Runtime $\mathcal{O}(n)$ if done well, $\mathcal{O}(n^2)$ also passes.



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Statistics: 37 submissions, 5 accepted, 28 unknown

I: Illuminated Stalls

Jeroen Op de Beek

Problem

- Given $n \leq 2 \cdot 10^5$ axis-aligned lines in 2D.
- Horizontal lines do not touch horizontal ones, same for vertical.
- Move one line to form a square.

I: Illuminated Stalls

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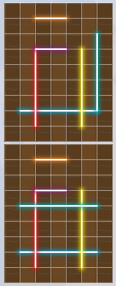
- Horizontal lines do not touch horizontal ones, same for vertical.
- Move one line to form a square.

Solution

- If there exist a rectangle, it is always possible.
- If there are more than $2n$ intersections, there exists a rectangle.
- We only look for U-shapes, where the new line is moved to the top.
- For a horizontal line look at its intersections.
- Fix the smaller of the two vertical lines.
- We only need to check the closest taller vertical line to the left and right.



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Implementation

- For simplicity, try all four 90 degree rotations separately.
- Calculate all intersections via a sweepline, quit if there are too many.
- Iterate over horizontal lines, sort intersecting vertical lines by decreasing height.
- Sweepline over the vertical line, lookup the neighboring lines in a set.
- Check if there already are upper horizontal lines at the correct height.
- Check which length are currently used and if the remaining longest one is enough.
- Careful: you may need to move one of the upper horizontal lines.

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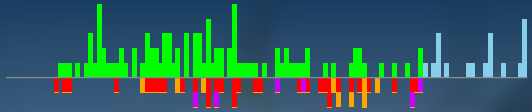
Statistics: 11 submissions, 0 accepted, 10 unknown

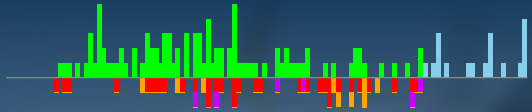


J: Juggling Keys

Markus Himmel

Problem

Given n people sharing an apartment with k keys going on q trips, find who needs to take a key such that no one arrives to an empty apartment without a key.



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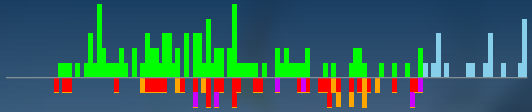
Observation

A trip only needs a key if it ends when the apartment is empty.



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- Simulate while keeping track of the number of people in the apartment.
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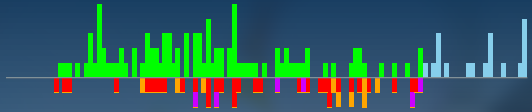

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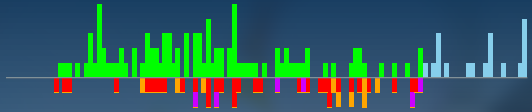
- Do a second simulation while keeping track of the number of keys in the apartment.
  - If this ever becomes negative, output "`impossible`".



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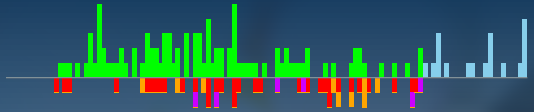

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  - If this ever becomes negative, output "`impossible`".
- Runtime: $\mathcal{O}(n \log n)$.

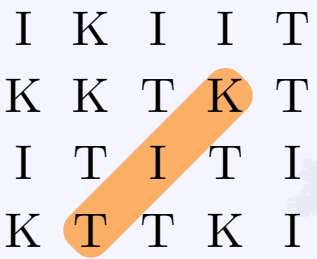
Statistics: 164 submissions, 98 accepted, 18 unknown

K: KIT Finding

Paul Wild

Problem

Construct an $h \times w$ grid of the letters 'K', 'I' and 'T' such that each letter occurs a given number of times and the word "KIT" appears exactly once when reading in the 8 possible directions.



K: KIT Finding

Paul Wild

Solution

- Start with "KIT" in the top left corner.
- Then place all the remaining 'T's, followed by all the 'K's and finally all the 'I's.
- No extra occurrences of "KIT" possible, as no 'I' can be between a 'K' and a 'T'.

K	I	T	T	T
T	T	T	T	K
K	K	K	K	I
I	I	I	I	I

K: KIT Finding

Paul Wild

Solution

- Start with "KIT" in the top left corner.
- Then place all the remaining 'T's, followed by all the 'K's and finally all the 'I's.
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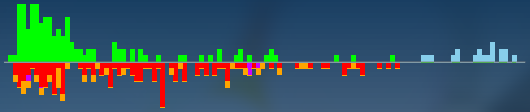
K	I	T	T	T
T	T	T	T	K
K	K	K	K	I
I	I	I	I	I

Statistics: 189 submissions, 118 accepted, 12 unknown

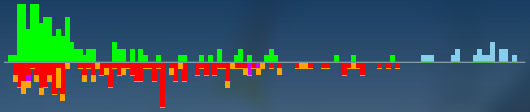


L: Last Christmas

Jeroen Bransen

Problem

Given n top-10 lists, which artist appears most often? If there is a tie, output who is most often number 1. If there is a tie, output who is most often number 2 and so on.



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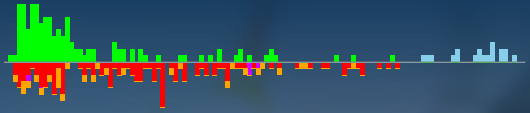
Problem

Given n top-10 lists, which artist appears most often? If there is a tie, output who is most often number 1. If there is a tie, output who is most often number 2 and so on.

Solution

- Count the appearances for each artist.
- Count for each artist and for each k how many number k hits they have.
- Find the best artist, do the tiebreaking according to the rules.

Runtime: $\mathcal{O}(n)$



L: Last Christmas

Jeroen Bransen

Problem

Given n top-10 lists, which artist appears most often? If there is a tie, output who is most often number 1. If there is a tie, output who is most often number 2 and so on.

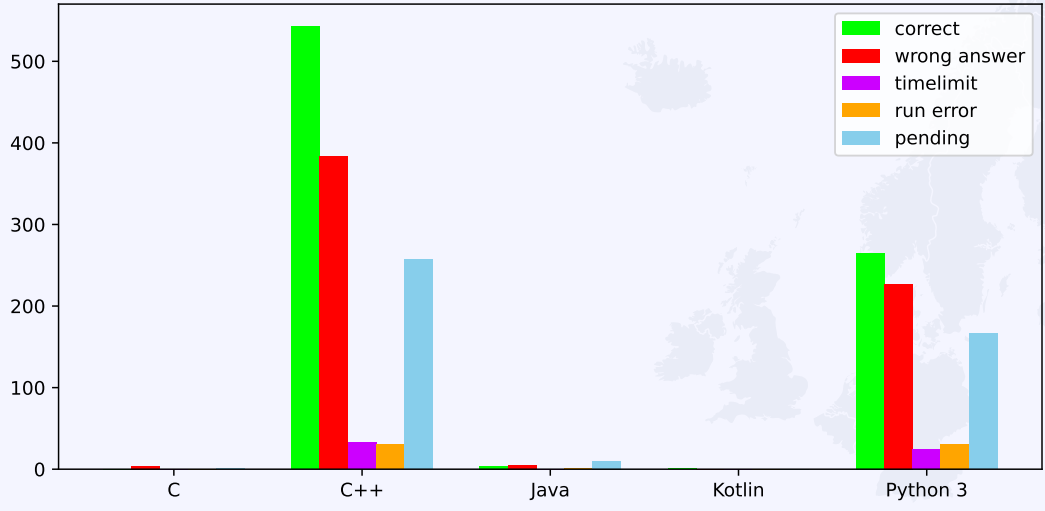
Solution

- Count the appearances for each artist.
- Count for each artist and for each k how many number k hits they have.
- Find the best artist, do the tiebreaking according to the rules.

Runtime: $\mathcal{O}(n)$

Statistics: 289 submissions, 125 accepted, 19 unknown

Language stats



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- 1413 secret test cases (last year: 1281) ($\approx 117\frac{3}{4}$ per problem!)
- 317 jury/proofreader solutions (last year: 356)
- The minimum[1] number of lines the jury needed to solve all problems is:

$$8 + 7 + 14 + 1 + 2 + 2 + 8 + 22 + 45 + 5 + 3 + 5 = 122$$

On average $10\frac{1}{6}$ lines per problem, down from 18 last year.

[1] With some code golfing, last year we golfed less