UKIEPC 2020

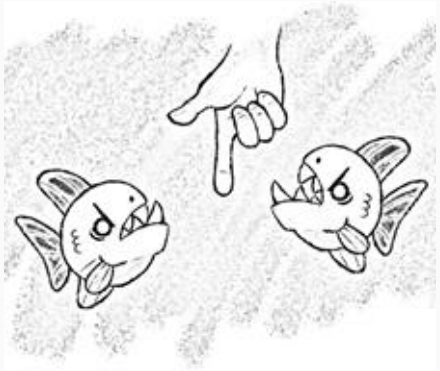




Summary and solution outlines

Problem Solutions

Note: Many problems this year are shared with BAPC (https://2020.bapc.eu/)



Aquarium

?? correct • solved at: ??:?? by

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University of ??

Author: **Freek Henstra**

Overview

- We need to line some piranhas up for a group photo.
- Putting a finger in the tank causes adjacent piranhas to start swimming toward the finger.
- Find the number of seconds of finger exposure needed to put every fish in its specified place.

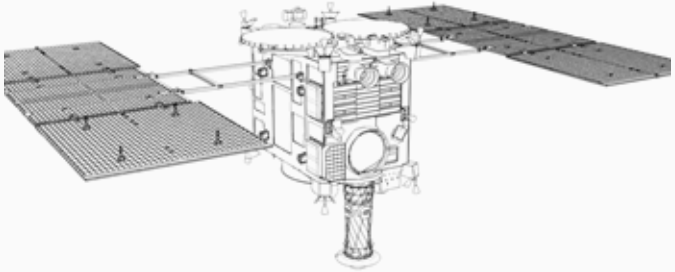
Aquarium - Solution

Techniques

- Intervals
- Greedy algorithms
- Amortisation

Algorithm

- Each fish needs to move by X_i places.
  - The number of finger placements to the right must be $\mathbf{X_i}$ more than the number to the left.
- Assume the number of placements to the left of the leftmost fish is $-\mathbf{X_0}$.
  - Then the next number must be **0**, the next after that must be $\mathbf{0+X_1}$, then $\mathbf{0+X_1+X_2}$, etcetera.
  - We need all values to be non-negative. Take the minimum of value and subtract it from everything.
- Now we need to check if this number of placements is feasible
  - The answer is guaranteed to be at most $O(N*K^2)$.
  - So we can just go from left to right making all valid moves.



Bidirectional

?? correct • solved at: **??:??** by
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Authors:
Ludo Pulles, Mike de Vries

Overview

- Write a number < 10^18 as sum of ≤ 10 palindromic numbers.

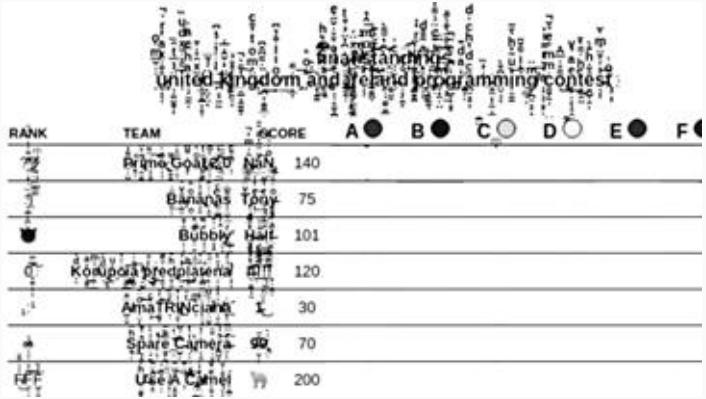
Bidirectional Code - Solution

Techniques

- Greedy
- Recursion
- Stubbornness

Algorithm

- Idea: construct the biggest balanced number less than n greedily.
- Example:
  - n = 970 894 988 875 162 603
  - p[1] = 970 894 987 789 498 079
  - n − p[1] = 000 000 001 085 664 524
  - p[2] = 000 000 001 085 555 801
  - n − p[1] − p[2] = 000 000 000 000 108 723
- Possible edge case: n = 10 ` : p = n − 1.
- To get k ≤ 5: run a brute force to express n as sum of three balanced numbers when n ≤ 200 000.



Corrupted Judge

?? correct • solved at: **??:??** by
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Author: **Boas Kluiving**

- Reconstruct a missing part of a contest scoreboard from other known parts.

Corrupted Judge- Solution

Techniques

- Logic
- Implementation
- Zalgo

Algorithm

- Starting at the last team fill in the corrupted column conservatively. The last team solved p[n]=1 problem.
  - For i=n-1,...,1 p[i] = p[i+1] + (1 if t[i] <= t[i+1] else 0)
  - If p[1] = p, then the scoreboard is non-ambiguous.
  - Else p[1] = p gives another correct scoreboard (ambiguous)
- Some special cases to deal with
  - If no team has solved any problem, it is not ambiguous.



Divvying Up

?? correct • solved at: **??:??** by
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Author: **Robin Lee**

Overview

- Three professionals (one not pictured) are going to earn some money from individual events
- Can they distribute the money equally?

Divvying Up - Solution

Techniques

- Integers

Algorithm

- We just need to know if the total is divisible by 3. So start by computing the total as the sum of the input array.
  - In python, sum(map(int, input().split())) does the job.
- Use your language's modulus operator (usually "%") to calculate the remainder from division.



Elevator Pitch

?? correct • solved at: ??:?? by
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Author:
Mees de Vries

Overview

- Build the least number of elevators so that all buildings become accessible.
- We need to count local maxima in the floor plan, but only once each.

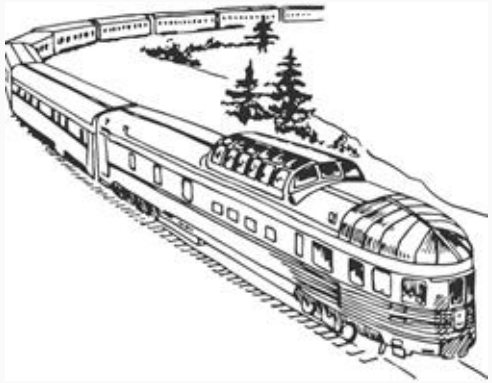
Elevator Pitch - Solution

Techniques

- Breadth-first search
- Implicit graphs

Algorithm

- Sort all of the locations in the grid by (descending) height
- Go through all of the locations in this order:
  - If the location is already visited, skip it.
  - Otherwise, run a flood fill (BFS) from that location to all lower/equal locations, and mark them as visited.
- Output the total number of flood fills needed



Family Fares

?? correct • solved at: **??:??** by
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Author: **Boas Kluiving**

Overview

- A number of people are travelling to the same place along shortest paths, and we can buddy some of them up with a group ticket.
- Group tickets cost a fixed amount per person and must be taken together.
- Which group ticket starting point should we choose (if we choose one at all)?

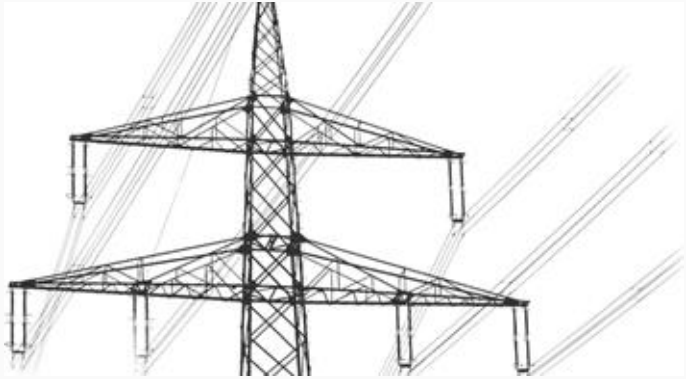
Family Fares - Solution

Techniques

- Dijkstra
- Memoisation
- Bitmasks

Algorithm

- We need to precompute a lot of shortest paths to the idyllic village (which is where the group ticket will always end up).
- For every family member mark all stations which are on shortest paths from their starting point to the idyllic village.
    - Optimise for higher numbers of people by using a bitset and ORing it with shortest-path neighbours.
- Iterate over all stations and compute the savings when using that station to buy the group ticket.



Generators

? correct • solved at: **??:??** by
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Author: **Timon Knigge**

Overview

- Install some power plants onto an island where everybody “lives on the edge” of a giant weighted cycle.
- To do this, pick some edges and vertices such that each vertex is connected to a marked vertex via a direct or indirect path.

Generators - Solution

Techniques

- Spanning Trees

Algorithm

- Transform it into a “minimum spanning tree” problem where every node has to be connected to a virtual “power” node.
- We’ll put this power node at the centre and connect it to everything else with a weight according to the cost of installing a power station there.
- Prim’s or Kruskal’s algorithms can do the rest.



Haughty Cuisine

?? correct • solved at: ??:?? by
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Authors:
Pim Spelier, Mike de Vries, Ragnar Groot Koerkamp, Robin Lee

Overview

- Solve an annoyance by picking a list of food items from a list of set menus at random.

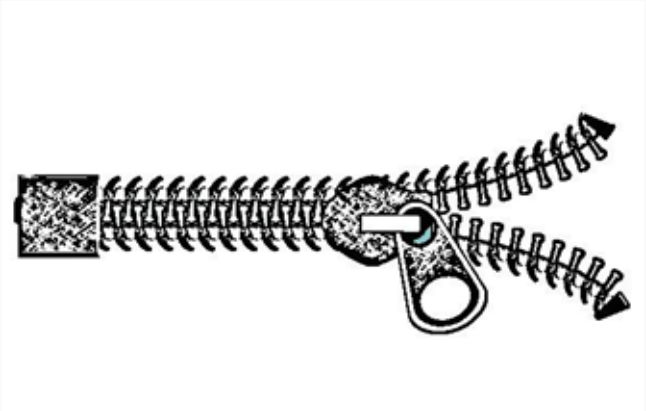
Haughty Cuisine - Solution

Techniques

- Implementation

Algorithm

- Read in the size of the first menu, and immediately print it back out again.



Incomplete Sort

?? correct • solved at: ??:?? by
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Author: **Jorke de Vlas**

Overview

- Sort an array by sorting half of it three times.

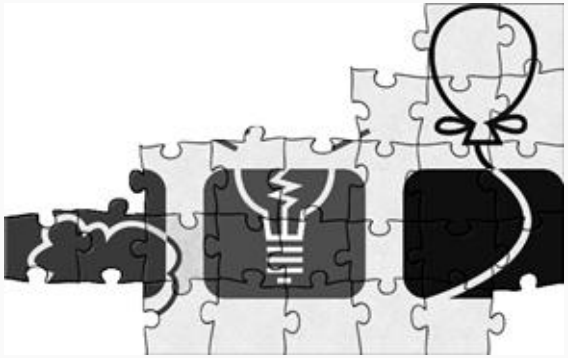
Incomplete Sort - Solution

Techniques

- Divide and conquer
- Permutations

Algorithm

- Idea:
  - In the first step, sort the first quarter.
  - In the second step, sort the second quarter.
  - In the final step, sort the remaining numbers.
- To accomplish this:
  - First step: Choose the first n/4 numbers and the positions of the first n/4 numbers, so that the first n/4 numbers are forced into the first quarter.
  - Second step: Choose the next n/4 numbers and positions, for the same reason.
  - Third step: Just sort everything else (n/2)



Jigsaw

?? correct • solved at: ??:?? by
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Author: **Mike de Vries**

Overview

- Determine whether a jigsaw puzzle is solvable from the numbers of each kind of piece.

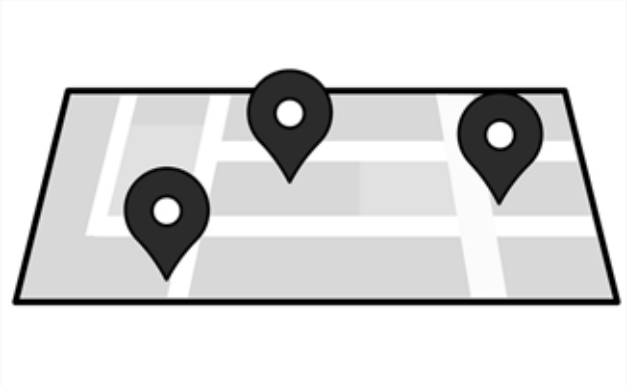
Jigsaw - Solution

Techniques

- Ad Hoc

Algorithm

- A jigsaw puzzle of size w · h contains:
  - 4 corner pieces
  - 2(h − 2) + 2(w − 2) edge pieces
  - (h − 2)(w − 2) center pieces
- This reduces the problem to a simple system of equations.



Kleptocrat

? correct • solved at: **??:??** by
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Author: **Jorke de Vlas**

Overview

- Given a connected undirected graph, find a path from A to N that minimizes XOR of the values on the edges.

Kleptocrat - Solution

Techniques

- Linear Algebra
- Cycles

Algorithm

- Observation: walking back and forth does not change the XOR-value since $x \oplus x = 0$.
- When there is a cycle starting from c with XOR-value v , we may walk from a to c, around the cycle, back to a and then to b giving a value of $w \oplus v$ where w was the value of a path from a to b.
- This is an equation over \mathbb{F}_2 and the v_i can be reduced with Gaussian Elimination giving 64 values.

Kleptocrat - Solution (cont.)

Techniques

- Linear Algebra
- Cycles

Algorithm

- See v_i as vectors in F_2^64 by writing v_i in base 2.
- The linear combinations form a subspace of dimension at most 64: find a basis, which has at most 64 elements.
- Now, given an initial path w, for i from 63 to 0, look if w has a 1 in the ith binary digit and check if there is a basis element with i as most significant digit, in which XOR w with this value.



Lost Map

?? correct • solved at: ??:?? by
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Author: **Robin Lee**

Overview

- Two map fragments (strings) are badly damaged and some items are replaced by “?”s
- Find how many ways you can overlay the two fragments so that no non-”?” values conflict.

Lost Map - Solution

Techniques

- FFT
- Convolution

Algorithm

- We can treat the “?” and non-”?” values completely separately.
  - We make two separate binary strings
    - One encoding “?” as 0 values and everything else as 1 values
    - One encoding “?” as several -1s and everything else as its binary representation (takes LogK bits where K is the number of directions)
  - If we reverse one array, then the **convolution** of both versions of the binary strings from each map can be used to find the number of bits matching each time
    - We need the number of bits across both convolutions to exactly equal the length of the string.
- Pitfalls: FFT needs to be **fast**.



Moderate Pace

?? correct • solved at: **??:??** by
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Author: **Bergur Snorrason**

Overview

- Print the median value at the same index of three different arrays.

Moderate Pace - Solution

Techniques

- Sorting
- Implementation

Algorithm

- Read in the three arrays and iterate from i=0 to i=n-1
  - Create a new list L with the three items at index i and sort it
  - Print L[1], and move onto the next.

Final Standings

http://domjudge.bath.ac.uk/

