A Alphabetical Aristocrats

Time limit: 2s **Problem Author: Maarten Sijm**

- Sort a list of $n \leq 1000$ Dutch surnames with lengths up to 50 based on the Dutch rules, lexicographically, according to the values of the ASCII characters.
- Consider only the part starting from the first capital letter.
- The surnames consist of English letters, spaces, and apostrophes (`A-Z`, `a-z`, ‘ ’, ‘`'`’).
- It is guaranteed that the part starting with the first capital letter is unique.
- Names have no leading, trailing, or consecutive spaces.
- For example, the surname `van den Hecken the Younger` is sorted according to `Hecken the Younger`.

Tavern Scene by Abraham van den Hecken the Younger.
CC0 on Wikimedia Commons

B Binary Search

Time limit: 4s **Problem Author: Nils Gustafsson**

- Given is an undirected simple graph G with $n \leq 3 \cdot 10^5$ vertices and $m \leq 3 \cdot 10^5$ edges.
- Each vertex v has a binary label $a_v \in \{0, 1\}$.
- We call a binary sequence $s = s_1 s_2 \ldots s_k$ *walkable* if there exists a walk $v_1 v_2 \ldots v_k$ in G with $a_{v_1} a_{v_2} \ldots a_{v_k} = s$.
- If every binary sequence is walkable, output "`infinity`". Otherwise, output the length of a shortest binary sequence that is not walkable.

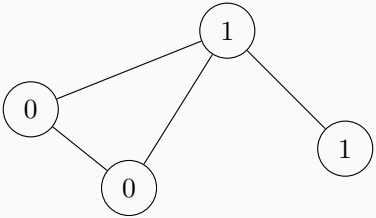


Illustration of Sample Input 1. The solution is 4, as there exists a binary sequence of this length that is not walkable, while every binary sequence of length at most 3 is walkable.

C Connect Five

Time limit: 2s **Problem Author: Thomas Beuman**

- Given are five locations in a city grid with square blocks, with coordinates up to 1000.
- Refurbish a set of streets in the grid, such that:
  - for any two locations there exists a shortest path between them that only uses refurbished streets; and
  - the total length of the refurbished streets is minimized.
- Output the minimum number of road segments that need to be refurbished.

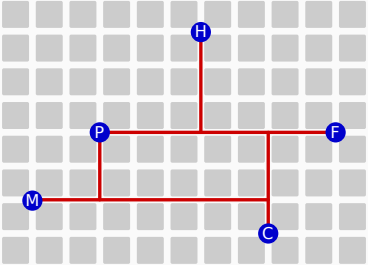


Illustration of Sample Input 1, with a possible way of refurbishing the minimum number of road segments (22).

D Dutch Democracy

Time limit: 2s **Problem Author: Thomas Beuman**

- There are $n \leq 60$ parties with $p \leq 10\,000$ seats each.
- Count the number of candidate coalitions meeting these two criteria:

  Strict Majority: The total number of seats held by the coalition must be strictly more than half of the total seats across all parties.

  No Superfluous Parties: The coalition must be minimal in the sense that removing any one party from the coalition would cause it to lose its strict majority.

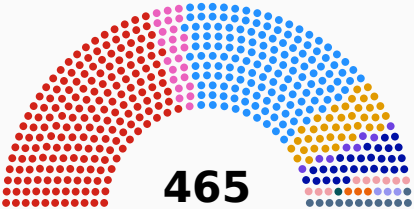
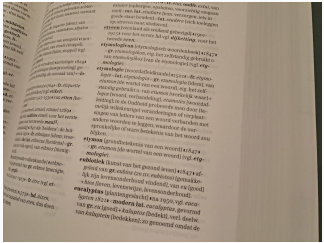


Illustration of Sample Input 2. In this example, there are 38 candidate coalitions.

E Evolving Etymology

Time limit: 1s **Problem Author: Nils Gustafsson**

- Create a new word from an existing word s ($|s| \leq 10^5$) by applying the following method up to 10^{18} times:
  - Take every second letter of $s + s$, starting with the first letter.
- For example, applying this method to the word "`etymology`" once would result in "`eyooytmlg`".



Van Dale Groot etymologisch woordenboek.
© Van Dale Uitgevers, used with permission

F Flowing Fountain

Time limit: 4s **Problem Author: Michael Zündorf**

- Bill pours champagne into a fountain with $n \leq 3 \cdot 10^5$ levels.
- If a bowl in some level is already filled up, then the champagne spills over to the first level below it with larger capacity.
- If the next larger level is also filled, the champagne spills over even further until eventually seeping into the ground.
- You are asked $q \leq 3 \cdot 10^5$ queries:
  - '+': Bill pours $x \leq 10^9$ litres of champagne into level ℓ.
  - '?': Bill wants to know how much champagne is in level ℓ.

Bill Poucher (ICPC Executive Director, on the right).
© Huawei, used with permission

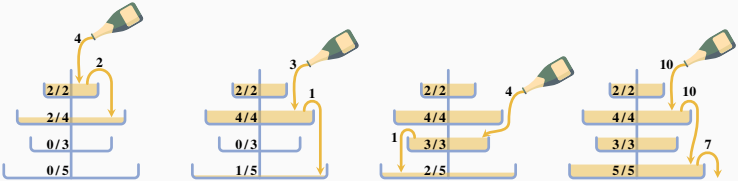
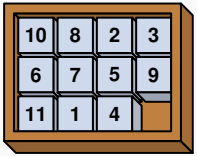


Illustration of Sample Input 2. The ith image visualizes the ith query of type '+'.

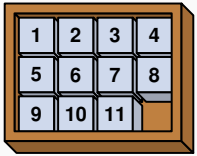
G Glued Grid

Time limit: 3s **Problem Author: Paul Wild**

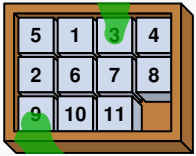
- Solve a sliding puzzle with size $h, w \leq 500$, where some tiles are glued.
- The empty square is at the bottom right position.
- Every glued tile is in its correct position.
- For each tile that can move, it is possible to have the empty square in its position instead.
- No glued tiles are encircled by tiles that can move.
- All tiles have distinct numbers on them, which must be sorted in ascending order.



Example of a 3-by-4 sliding puzzle, corresponding to Sample Input 1.



The same sliding puzzle, after solving.



Example of a sliding puzzle with glued tiles, covered in green goo. This example is possible to solve, corresponding to Sample Input 3.

H Hash Collision

Time limit: 1s **Problem Author: Reinier Schmiermann**

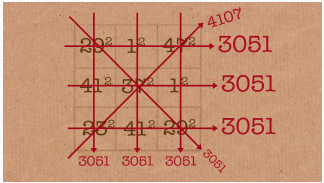
- There is a hidden function $f\colon \{1, 2, \ldots, n\} \to \{1, 2, \ldots, n\}$, where $n \leq 2 \cdot 10^5$.
- You may ask at most 1000 times for the value of $f^c(r) = \underbrace{f(\cdots f(}_{c \text{ times}} r) \cdots)$ for c and r in $\{1, 2, \ldots, n\}$.
- Find values of c and r such that $f^c(r) = c$.
- If there are multiple valid solutions, you may output any one of them.
- The interactor is not adaptive: the hidden function f is fixed up front, and does not depend on your queries.
- A testing tool is provided to help you develop your solution.

Silhouettes free to use from pxfuel.com

I It's a Kind of Magic

Time limit: 4s **Problem Author: Michael Zündorf**

- For $t \leq 10^5$ values of $n \leq 10^{18}$, count the number of multiplicative magic 3×3 squares with product at most n.
- All nine numbers must be positive and distinct.
- The *products* along all rows, columns, and diagonals have to be equal.



The Parker Square.
© Brady Haran, used with permission

18	1	12
4	6	9
3	36	2

Figure 1: Multiplicative magic square with product 216 along all rows, columns and diagonals.

J Jib Job

Time limit: 1s **Problem Author: Paul Wild, Ragnar Groot Koerkamp**

- Given are $n \leq 500$ cranes, with coordinates and heights up to 10 000.
- For each crane, output the positive integer length of its jib in metres, such that the covered area is maximized.
- If there are multiple optimal solutions, you may output any one of them.

Pixabay Content Licence by tonisun on Pixabay

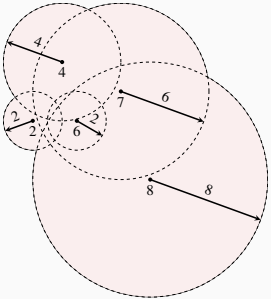


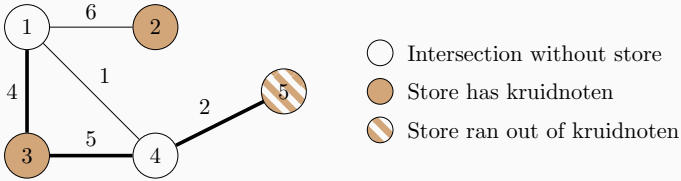
Illustration of Sample Input 3. The number at the centre of each circle indicates the height of the crane at that position. The number at each arrow indicates the length of the jib for that crane.

Kruidnoten

Time limit: 4s **Problem Author: Andreas Grigorjew**

- You are a given an undirected, weighted graph of $n \leq 2 \cdot 10^5$ vertices and $m \leq 2 \cdot 10^5$ edges.
- $k \leq n$ of the vertices contain a store that *may* sell kruidnoten.
- Store i sells kruidnoten with probability $0 < p_i \leq 1$.
- Karlijn takes a path from vertex 1 to vertex n that must contain at least one store that sells kruidnoten.
- Find the expected length of a shortest path from 1 to n.

Kruidnoten, a typical Dutch snack.
CC BY 4.0 by Hanno Lans
on Wikimedia Commons



A possible situation from Sample Input 1, where not every store is stocked with kruidnoten.
In this case, Karlijn buys the kruidnoten at the store at intersection 3, and the shortest path has length 11.

Limited Library

Time limit: 2s **Problem Author: Vitaly Aksenov**

- You have a bookcase with $n \leq 10^5$ shelves with given heights up to 10^9.
  - Each shelf fits at most $x \leq 1000$ books on a full shelf (without art piece).
  - Each shelf fits at most $y < x$ books on a shelf with art piece.
- You have $m \leq 10^5$ books with given heights up to 10^9.
  - All books have the same width.
- If possible, you should fit all books on the shelf, and output the largest number of art pieces you can place. Else, output "impossible".

The many bookshelves in the TU Delft library.

Illustration of Sample Input 1.
Three shelves can have art pieces in the hatched areas, while still fitting all new books.

M Mouse Trap

Time limit: 3s **Problem Author: Khaled Ismaeel**

- You are given a convex polygon with n vertices ($3 \leq n \leq 2 \cdot 10^5$), with a mouse sitting at each vertex.
- A cat jumps to some point inside that polygon.
- For any location of the cat one can count the number of *encirclements*: sets of three mice such that the cat is in the triangle spanned by the mice.
- Find the expected value for the number of encirclements when the location of the cat is uniformly random inside the polygon.
- The coordinates x, y are up to 10^7 in absolute value.
- The absolute or relative error of your answer must be at most 10^{-4}.

Medea with a mouse.

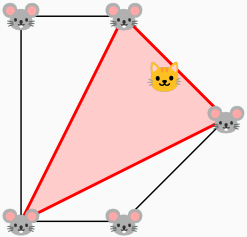


Illustration of Sample Input 2, showing one of the three encirclements in the case where Medea jumps to $(1.4, 1.4)$.