# Day 4: Problem Analysis

Niyaz Nigmatullin

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#### Day 4: Problem Analysis

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Problem A

Problem E

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Problem G

# Problem A. Headshot

### Statement

- You are playing russian roulette
- Your opponent already tried to shoot himself, and survived
- What is your strategy either you should rotate the cylinder or not?

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# Problem A. Headshot

## Solution

 Let's compute the probability of surviving, when not rotating

▶ Before the first shoot: 01001010

Before the second shoot: 01001010

• Probability to survive:  $\frac{C_{00}}{C_0}$ 

► Let's compute the probability of surviving, when rotating

• Probability to survive:  $\frac{C_0}{n}$ 

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# Problem A. Headshot

## Solution

- Compare this two numbers as:  $\frac{C_{00}}{C_0} < \frac{C_0}{n} \Leftrightarrow C_{00}n < C_0C_0$
- ▶ No need to use double
- ► If you use double, check two numbers might be equal, but precision errors make them not equal on the machine

```
int compare (double a, double b) { if (Math.abs(a - b) < 1e-8) reutrn 0; return a < b ? -1 : 1; }
```

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# Problem B. Alien communication masterclass

## Statement

- ► Compose an expression which:
  - ▶ Holds in the given bases
  - Doesn't hold in all other bases

## Solution

ightharpoonup Next expression is zero only in k base

$$10 \underbrace{-1 - 1 - \dots - 1}_{\text{k subtractions}} = 0$$

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# Problem B. Alien communication masterclass

$$(10\underbrace{-1-1-\cdots-1}_{\text{a}_1 \text{ subtractions}}) \times \\ \times (10\underbrace{-1-1-\cdots-1}_{\text{a}_2 \text{ subtractions}}) \times \cdots \times \\ \times (10\underbrace{-1-1-\cdots-1}_{\text{a}_N \text{ subtractions}}) = 0$$

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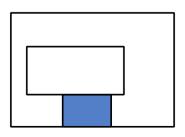
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# Problem C. Grave

### Statement

- You are given a rectangle with a rectangular hole
- ▶ You are to place  $w \times h$  rectangle inside it



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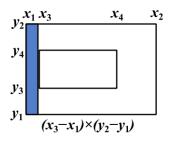
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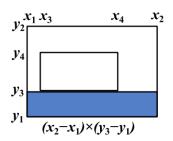
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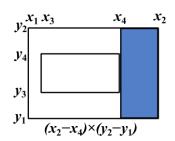
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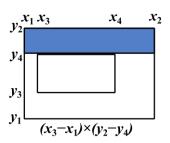
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# Problem C. Grave









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# Problem C. Grave

## Solution

- New rectangle has to fit into one of maximal rectangles
- ▶ Time complexity: O(1)

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# Problem D. Bureacracy

### Statement

- Find not cancelled laws
- May cancel a canceling law

# Solution

- Starting from the last statement
- Active
  - Apply an action
- Canceled
  - Skip

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Problem B

▶ 1. declare

Problem D

2. cancel 1

Problem

3. declare

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▶ 4. cancel 2

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▶ 5. cancel 3

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- ▶ 1. declare
- 2. cancel 1
- ▶ 3. declare
- 4. cancel 2
- ▶ 5. cancel 3

# n H

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- ▶ 1. declare
- ▶ 2. cancel 1
- ▶ 3. declare
- ▶ 4. cancel 2
- ▶ 5. cancel 3

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- ▶ 1. declare
- ▶ 2. cancel 1
- ▶ 3. declare
- 4. cancel 2
- ▶ 5. cancel 3

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- 1. declare
- ▶ 2. cancel 1
- ▶ 3. declare
- 4. cancel 2
- ▶ 5. cancel 3

# Nigmatullin

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Analysis Nivaz

Problem D

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### Statement

Count the contest characteristics

The contest header may contain arbitrary number of lines Team = Time R. Revda STU + + +2 +1 -9 4 9274 Girvas NU #1 + + -1 . -11 2 321 Kargopol SU -4 Utorgosh SU -5 5 Dubrovno SU 6 Girvas NU - 2 -5 -99

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# Weird things

```
The contest header may contain arbitrary number of lines
```

Team A B C D E = Time R

```
Revda STU + + +2 +1 -9 4 9274 1

Girvas NU #1 + + -1 . -11 2 321 2

Kargopol SU + -3 + . -4 2 321 2

Utorgosh SU . . . + -5 1 122 4

Dubrovno SU . + -1 . -4 1 123 5

Girvas NU - 2 . . . -5 -99 0 0
```

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### Header

- Search for header
  - Problem letters
  - First word is Team
  - Line of minuses
- Number of problems
  - From the header

# Table body

- Tokenize by spaces
- Look from the end
  - Use the number of problems

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### Niyaz Nigmatullin

# Vainness

► Teams who didn't solve anything

# Oversimplification

► Teams who solved everything

# Evenness

Spaces in the number of solved problems

# Unsolvability

► Problems not solved by anyone

Problem D
Problem E

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# Instability

 Teams who took a higher place, but didn't solve a problem

```
      Team
      C
      = Time R

      Revda STU
      +2 4 9274 1

      Girvas NU #1
      -1 2 321 2

      Kargopol SU
      + 2 321 2
```

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Problem 1

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# Negidealness

- ► Formula: 1.030 V + 3.141 O +
- ▶ 2.171 E + 1.414 U +
- $(I_1 + I_2 + \cdots + I_P)/P$

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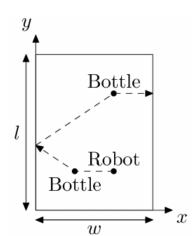
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### Statement

- Remove all the bottles
  - As soon as possible



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## Start and finish

- Start
  - To the first bottle
  - Straightforward
- ► Finish
  - From the last bottle
  - ► To the nearest boundary

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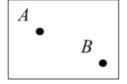
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# Between the bottles



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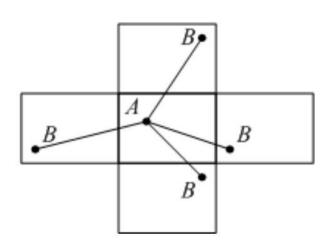
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# Problem F. Kitchen Robot Between the bottles



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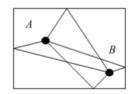
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Problem F

# Problem F. Kitchen Robot Fold up



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Problem F

## Solution

- Transition lengths are known
  - Traveling salesman problem
- Dynamic programming on subsets
  - ► F[A][v] shortest path to get to bottle v, collecting all the bottles from set A
  - To compute: try all the bottles u as the previous one, and exclude bottle v from the set
  - ▶ Time complexity:  $O(2^n \cdot n^2)$

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# Problem G. Asteroids

### Statement

- You are given two polyhedra
- ► Find the minimum distance between their centers of mass

## Solution

- ► Find the faces of each polyhedron
- ► Iterate over all triples of points, if all other points are on one side of the plane, then it's a face

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# Problem G. Asteroids

# Finding center of mass

- Choose one vertex
- Choose all triples of consecutive points from all the faces
- Polyhedron broke into tetrahedrons
- Center of mass of tetrahedron is just the coordinate average of points
- ► Assume that all mass of each tetrahedron is located in its center of mass
- Now find the mass average of these points, assuming that mass is proportional to the volume

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# Problem G. Asteroids

# Finding minimum distance

- Find minimum distance from center of mass to outside of polyhedron
- Just minimum of all distances to all the faces as planes

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# Problem H. Galaxy interconnection

### Statement

- Given a graph
  - Contains a cycle of size k
- Paint in k colors
  - Neighbors have different colors
- From each vertex there should be a path of k vertices of k different colors

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# Problem H. Galaxy interconnection

## Solution

- Consider a certain order of colors
- Paint the cycle in k colors in order
- DFS the other vertices from the cycle
  - Paint in some unused color which goes (in order) after a used one
- For unvisited vertices choose the color in order

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