

KTH Challenge 2014 Solutions

April 13, 2014

Jury

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- Ulf Lundström (KTH/Stanford)
- Lukáš Poláček (KTH/Spotify), head of jury
- Marc Vinyals (KTH)

F – Falling Mugs

Problem

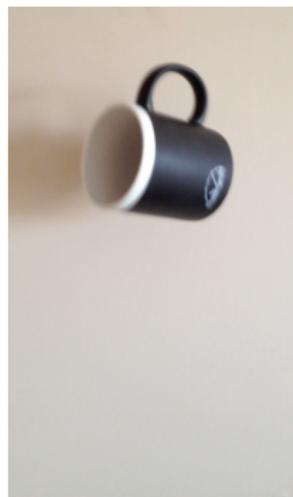
Find n_1 and n_2 such that $n_2^2 - n_1^2 = D$.

Solution

- Want to solve:

$$(n + x)^2 - n^2 = 2xn + x^2 = D$$

- Note that $x \leq \sqrt{D}$
- Try each x , solve for n in $O(\sqrt{D})$ time
- Or try both for $O(D^{3/2})$ time
- Or look at equation and conclude that we can take $x \in \{1, 2\}$ for constant time



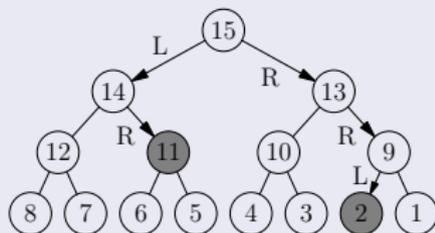
281 submissions, 48 correct, first at 0:12:05.

A – Numbers on a tree

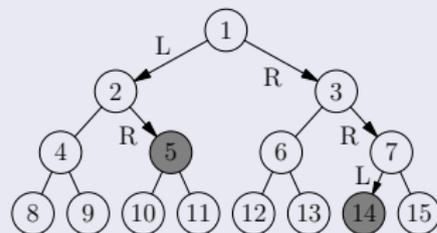
Problem

Find the label of a node described by a path from the root

Solution



(a) Original tree



(b) $16 - x$

Replacing number x with $2^{H+1} - x$ leads to the classic tree labelling.

121 submissions, 65 correct, first at 0:05:46.

C – Cow Crane

Problem

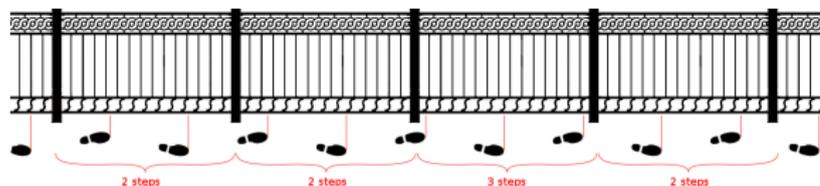
Check if the two cows can be picked up and moved such that they are placed at the new position before their meal.

Solution

- You might want to temporarily drop off a cow at a certain position.
- Try all possible movements of the crane, check if one of them works.
- Or do it greedily - a couple of cases to think about to get it right.

Statistics: 88 submissions, 37 correct, first at 0:47:52.

I – Count von Walken's Fence



Problem

Check if distance between poles is feasible

Solution

- Starting point $0 < x < 1$ from first fence post
- For each i we get bounds on x

$$x + \sum_{j=1}^i c_j < D \cdot i < 1 + x + \sum_{j=1}^i c_j$$

- Check lower bound smaller than upper bound

G – Intercept

Problem

Find vertices crossed by all shortest paths



Solution

- Construct graph of shortest paths (Dijkstra)
- Find articulation vertices

Solution

- Count how many shortest paths reach a vertex
- Too large number? Hash it!

58 submissions, 8 correct, first at 1:06:26.

B – Absurdistan Roads II



Problem

Calculate the probability that a particular random graph is connected

Solution

- There are $(n - 1)^n$ different graphs
- Let c_k be the number of connected graphs of size k .
- We have

$$c_k = (k - 1)^k - \sum_{i=2}^{k-2} c_i \binom{k-1}{i-1} (k-i-1)^{k-i}$$

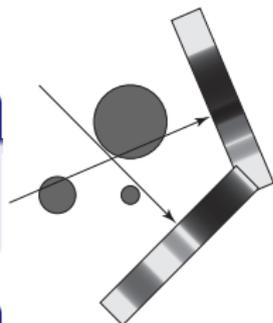
- The sum counts the number of disconnected graphs. Index i is the size of the component containing node 1.

9 submissions, ?? correct, first at 0:19:42.

D – Tomosynthesis

Problem

Find largest range of angles where no circles overlap.



Solution

- Find overlap range for each pair of circles.
- Go through the sorted list of the starts and ends of these intervals to find ranges of no overlap.

Statistics: 2 submissions, 2 correct, first at 1:06:02.

H – Radar

Problem

Find the smallest z within y_i of x_i modulo m_i for $i = 1, 2, 3$.



Solution

- Smallest z will have $z \equiv x_i - y_i \pmod{m_i}$ for some $i = 1, 2, 3$
- Try all $O(y^2)$ possibilities for the remaining two equations
- Solve modular congruences with Chinese Remainder Theorem
- Special case: $z = 0!$

40 submissions, ?? correct, first at 2:37:50.

E – Pizza Problems



Problem

Find choice of toppings so that everyone gets $> 1/3$ of their wishes, assuming it is possible to make everyone get $\geq 2/3$ of their wishes.

Solution

- Flip choice for a random unsatisfied wish for some friend who is not yet happy.
- With probability $\geq 1/2$ this takes us one step closer to a solution.
- Such a random walk converges in $O(\#\text{toppings}^2)$ steps with high probability.

(Generalization of Papadimitriou's 2-Sat algorithm.)

7 submissions, ?? correct, first at ???.

This was fun! When is the next contest?

- We train every two weeks at KTH, check www.csc.kth.se/contest.
- Next training on Thursday April 24 at 17:15 in Orange.
- Nordic Championships in October, North-western Europe qualifier in November.
- Plenty of other online competitions every week.
- Subscribe to our calendar and RSS feed.

Boot camp June 6 – June 8

- 3 days on Möja in the archipelago.
- Lectures, trainings and fun activities.
- By invitation only.
- Also camp for Swedish IOI team, Linköping University and FAU-Erlangen Germany.



Photo by The U.S. Army

Guide To Programming Contests

- <http://contest-wiki.csc.kth.se/>
- Written by Lukáš.
- The first training program for programming contests.
- Well received in the contest community.