Introduction to Competitive Programming

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Outline

- What is CP?
- History
- Why CP?
- CP challenges
- Famous Competitions
- Where to start

What is CP?

Competitive Programming

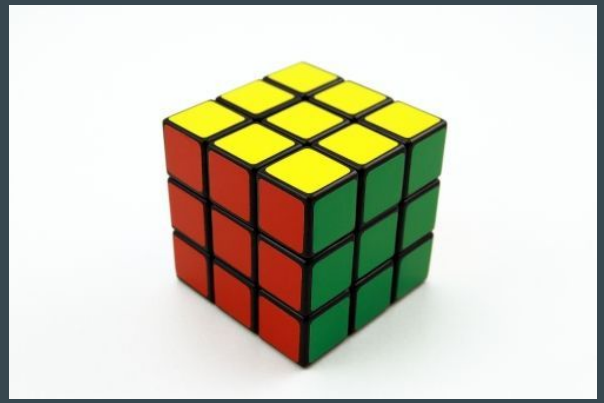
Sport Programming

Algorithmic contests

Writing a program to solve a problem

- Correct solution
  - Online judging systems (10 years)
- Limited time
- Time and memory constraints

- Sample problem: Serial



ICPC History

1970 - First ICPC Competition (with 7 contestants!)

2023 - 47rd ICPC Competition

17000 teams, 3200 universities.

Why CP?

- Coding abilities
- Problem-Solving abilities
- CV

- Fun!

CP is fun!

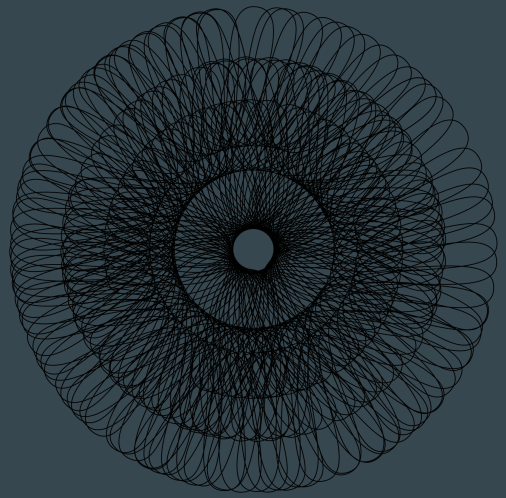
- Excitement
- Joy of problem-solving
- Team-work
- Community
- On-site events
  - (excursions, trips, prizes)

See the clip!

The joy of problem solving

1. Complexity

- Example: input x, print x^4
  - Solution 1:
    - print(x*x*x*x) → 3 multiplications
  - Solution 2:
    - y = x*x
    - print(y*y) → 2 multiplications
- What if we want to calculate x^1024?
  - Solution 1 → 1023 multiplications
  - Solution 2 → 10 multiplications
- What about 11529215046068469 76 ?!



The joy of problem solving

2. Creativity

- Example 1: Serial
- Example 2: Saving Data
- Example 3: Möbius Strip

Problem E : Möbius Strip

A Möbius strip is obtained by taking a long strip of paper, twisting the paper through 180 degrees (or in other words, a half-twist) and then, joining one end back to the other end of the strip. A möbius strip is shown in the figure to the right.

Instead of performing only one half-twist, we can also do zero, two, three, four, or more half-twists, and then tape the two ends. The resulting shape for three, four, and five half-twists respectively looks like below:

The joy of problem solving

3. Knowledge

- Algorithms
- Math
  - Chair game
- Implementation speed and precision
  - ICPC 2019: Karel the Robot

- ... And everything else!

What I mean by “everything else”?

- **ACM-ICPC 2014 World Finals - Crane Balancing**

Problem C
Crane Balancing
Time Limit: 1 second

Wherever there is large-scale construction, you will find cranes that do the lifting. One hardly ever thinks about what marvelous examples of engineering cranes are: a structure of (relatively) little weight that can lift much heavier loads. But even the best-built cranes may have a limit on how much weight they can lift.

The Association of Crane Manufacturers (ACM) needs a program to compute the range of weights that a crane can lift. Since cranes are symmetric, ACM engineers have decided to consider only a cross section of each crane, which can be viewed as a polygon resting on the x-axis.

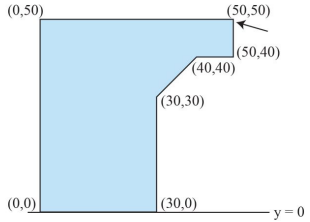


Figure C.1: Crane cross section

- **ACM-ICPC 2014 World Finals - Skiing**

For simplicity, use a two-dimensional coordinate system where the skier starts at position (0,0) and where “downhill” corresponds to the direction of the positive y-axis.

Assume the y-component of the athlete’s velocity is a constant v_y. The athlete can change speed laterally (in the x-direction), but the skiing equipment limits this to a maximal lateral acceleration a_{max}. The skier starts with a lateral velocity of 0.

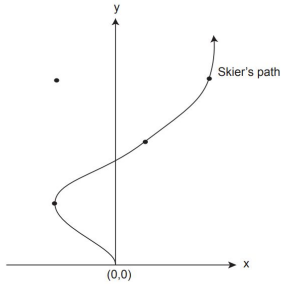


Figure J.1: Downhill ski path passing over three targets

In Figure J.1 (which corresponds to the first sample input), the optimal path passes over three out of four possible targets. If a_{max} were smaller, then the skier might be able to pass over only two or fewer of the targets.

What I mean by “everything else”?

- ACM-ICPC 2015 World Finals - Cutting Cheese

Problem D
Cutting Cheese
Time limit: 3 seconds

Of course you have all heard of the International Cheese Processing Company. Their machine for cutting a piece of cheese into slices of exactly the same thickness is a classic. Recently they produced a machine able to cut a spherical cheese (such as Edam) into slices – no, not all of the same thickness, but all of the same weight! But new challenges lie ahead: cutting Swiss cheese.

Picture by Jon Sullivan via Wikimedia Commons

Swiss cheese such as Emmentaler has holes in it, and the holes may have different sizes. A slice with holes contains less cheese and has a lower weight than a slice without holes. So here is the challenge: cut a cheese with holes in it into slices of equal weight.

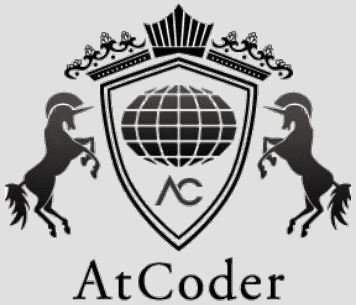
- ACM-ICPC 2016 World Finals - Polygonal Puzzle

Problem H
Polygonal Puzzle
Time limit: 20 seconds

During last year’s ACM ICPC World Finals in Marrakesh, one of the judges bought a pretty wooden puzzle depicting a camel and palm trees (see Figure H.1). Unlike traditional jigsaw puzzles, which are usually created by cutting up an existing rectangular picture, all the pieces of this puzzle have been cut and painted separately. As a result, adjacent pieces often do not share common picture elements or colors. Moreover, the resulting picture itself is irregularly shaped. Given these properties, the shape of individual pieces is often the only possible way to tell where each piece should be placed.

Figure H.1: The judge’s wooden puzzle.

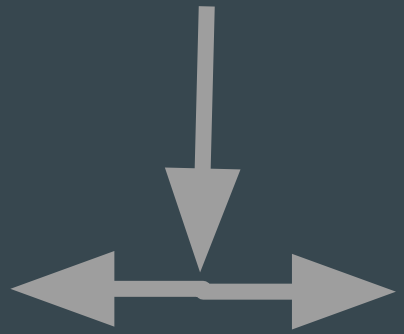
Famous Competitions



code jam

Where to start?

Learn coding in C++!
(Python and Java might work too)



Learn algorithms and math

Practice

Important Things to Master

1. Problem-Solving
2. Implementation
3. Knowledge
    a. Algorithms
    b. Combinatorics
    c. Graph
    d. Geometry
    e. Math

This Course

Algorithmic Thinking

Data Structures

String Algorithms

Graph and Tree Algorithms

Coding Techniques

Last but not least:

Don't afraid to be a beginner!

Thank you!