Competitive Programming
Lecture 1

Yongwhan Lim
Monday, September 11, 2023

Christian Yongwhan Lim

Education

Part-time Jobs

Full-time Job

Workshops

Stanford ENGINEERING | Stanford Computer Forum

Coach/Judge

icpc International Collegiate Programming Contest

icpc.foundation
advancing the art and sport
of competitive programming

https://www.yongwhan.io

Instructor's (Terse) Background

- **Email**: yongwhan.lim@columbia.edu

- **Associate in Computer Science** at Columbia;
- **ICPC Head Coach** for Columbia University;
- **Internship Manager** at ICPC Foundation;
- **ICPC North America Leadership** Team;
- **CEO** (Co-Founder) in a Stealth Mode Startup;
- **Owner** in Christian and Grace Consulting LLC;
- **Visiting Instructor** at Cornell-Tech;

https://www.yongwhan.io

Wonderful TAs!

- **Akash Nayar**
  - Email: akn2120@columbia.edu
  - Administrative tasks (e.g., auto-grading, etc)

Akash Nayar (TA)

- SEAS Senior
- 1.5 years of Competitive Programming experience
- Interested in Machine Learning and AI
- Python -> C++ convert (for CP)

Wonderful Course Designer!

- **Grace Lim**
  - Email: gc3000@columbia.edu

Grace Lim (Course Designer)

- GS Junior
- Worked in Google before: at Google Play for ~4 years.
- Won a t-shirt from TopCoder Open before.
- I love CS and Psychology!
- Will bring a lot of enthusiasms here!

NOW... IT IS ABOUT YOU!

- Please fill out a survey on:
  https://bit.ly/competitive-programming-survey

  NOW!

- I will give you **few minutes** to fill out the survey :)

Lectures

- **Mondays** from **7pm ET** to 9:30pm ET
- @ **1127 Seeley W. Mudd**, in-person only!
- All course materials will be posted on Columbia Courseworks:
  https://courseworks2.columbia.edu/courses/179364

Prerequisites

- GPA of 3.7+ is highly recommended.
- **COMS 3134** (Data Structure in Java) **or**
- **COMS 3136** (Essential Data Structures in C/C++)

AND

- **COMS 3157** (Advanced Programming)

AND

- **COMS 3203** (Discrete Mathematics).
- Knowledge of C++ or Java or Python is highly recommended.

Optional Textbooks

- Competitive Programming 4, Halim et. al.

- Guide to Competitive Programming, Laaksonen

(Growing) Short List of Useful Websites

- Please take a look as needed: **Link**

Terse Guides

- Please take a look as needed: **Link**

Allowed Languages

- **C/C++**

- Java

- Python

Course Objectives

- Upon successful completion of the course, you will have mastered the fundamental knowledge required to succeed in:
  - Competing with confidence in **ICPC series**: Columbia Locals (CULC), Greater New York Regionals (GNYR), North America Championships (NAC), and World Finals (WF).
  - Passing with confidence in any entry-level technical interview at the top-tier quant (e.g., HRT, Jane Street) or tech companies.
  - Attaining **high ratings** in any competitive programming websites (e.g., CodeForces, AtCoder, LeetCode, and etc.)

Course Objectives

- We will go over **topics** and **strategies** required to succeed in the competitive programming contests!

Proper Citation

- As written explicitly in **"Course Contract"**,
- If you refer to an additional resource, you **MUST** cite the source using comments.
- To put the citation at the top of the code,
  - In C++, for example, you MUST use "//" or "/* */".
  - In Python, you MUST use '#'.
- **Take a special care with the proper citation as, there is:**

  NO EXCEPTION TO THIS CITATION RULE

- Failure to abide by the rules above will result in automatic failure in this class. In addition, you will be referred to the office.

Proper Citation

- **CodeForces Contest Rules** (**MikeMirzayanov**)

- Especially, take a careful note of the "Can-do's and Can't-do's" section.

Weekly Presentations (20%)

- For the presentation, you need to pick a problem from a list of questions that are posed at the end of the lecture.

- We will have a first-come-first-serve basis to pick a problem or two from a list of problems related to the lecture topic.

Weekly Live Contests (40%)

- Active participation in **LIVE** programming contests from **CodeForces**.

- You will receive **one** point per correctly solving a problem from live contests.

- You are required to hit at least **150** points by the end of the course.

Weekly Live Contests (40%)

- Please note that you are required to participate in the **LIVE** contest when the contest is held (so, in particular, a virtual contest will **NOT** count).

- Any points earned beyond 150 points will get counted as an extra credit for the live contest grade.

Weekly Practice Contests (20%, default: online)

- **Online Training in Competitive Programming (OTCP)**
  - **Weekly**: Mondays 9am ET
  - **Weekend**: Fridays 5pm ET to Sundays 5pm ET (Remote)

- You are required to attend **at least 20** practice contests.
- **1%** per each attended practice contest;
- **.5%** per each extra practice contest beyond 20, uncapped;

Weekly Practice Contests (20%, default: online)

- You are expected to participate with a team of **up to <u>three</u>** students, where a solo contest is permissive too.

- In each practice contest, all the team members must be present, with an expectation of equal contributions.

Weekly Practice Contests (20%, default: online)

- You may change team members during the semester but you need explicit permission from the instructor if you wish to do so.

- For those who do not already have a team, the practice will be done individually until a team can be matched.

Weekly Practice Contests (20%, default: online)

- When prompted to explain a solution your team submitted in the practice contest, one of your team members is expected to explain the full solution to the problem.

- If you solve a problem during the practice contest, you will be awarded **.5 live contest points** per problem.

1:1 Mentorship (20%)

- You are required to sign up for 1:1 mentorship sessions for **10** times throughout the semester on a regular schedule (e.g., you cannot sign up for all 10 sessions at the beginning or at the end of the course).

- The purpose of the mentorship is to track your progress and make sure I can explicitly help you on missing dimensions.

1:1 Mentorship (20%)

- **Sign up** using:
  https://bit.ly/fall-2023-mentorship-christian

- **Please fill out the form now.** I will give you a few minutes to do so!

Request 1:1 Meeting, through Calendly

- Use https://calendly.com/yongwhan/quick-chat-blitz to request one-off 1:1 meeting.

- Barring extraordinary circumstance, please use time slot **between 9am ET and 9pm ET**; if you have an exceptional case, please send me an email (yongwhan.lim@columbia.edu) to describe the issue. thank you!

Deliverables

- Nothing, since it will be **auto-tracked**!

Attendance

- Attendance is **required**.

- You have **one** automatic excused absence.

- You are responsible for delegating presentations if you signed up for the presentation slot but cannot show up.

NO! Exams

- **No(!)** midterm or final!

ICPC North America Qualifier (NAQ)

- **<mark>Required!</mark>**
- **<mark>In-person ONLY (Online for CVN)</mark>**
- **Saturday, September 30, 2023**.
- **Location: TBD**
- You will receive assignment points equivalent to the number of solutions you correctly solved, if you successfully participate in this contest.
- This is an individual, not a team, contest.
- If you do well, this will be used to form your team to represent Columbia at the Greater New York ICPC Regionals.
- To express your interest on participation, please use [this form](#).

ICPC Columbia University Local Contest (CULC)

- **<mark>Required!</mark>**
- **<mark>In-person ONLY (Online for CVN)</mark>**
- **Sunday, October 15, 2023 from 1pm to 6pm**.
- **Location: TBD**
- You will receive assignment points equivalent to the number of solutions you correctly solved, if you successfully participate in this contest.
- This is an individual, not a team, contest.
- If you do well, this will be used to form your team to represent Columbia at the Greater New York ICPC Regionals.
- To express your interest on participation, please use [this form](#).

ICPC Greater New York Regional (GNYR)

- **Required! (if eligible)**
- **In-person ONLY**
- **Sunday, October 29, 2023**
- **Location: Uris Hall @Columbia University**
- You will receive assignment points equivalent to the number of solutions you correctly solved, if you successfully participate in this contest.

- You may count this contest for one of your **20 practice contests** requirements.

ICPC NAQ / CULC / GNYR

- You may count these contests for one of your **20 practice contests** requirements.

ICPC Team Selection

- Please fill out the following Google form for your (ICPC) team selection preference:

   https://bit.ly/2023-columbia-icpc

Course Structure

- Each week, we will have:
  - (in-person) On Mondays, there will be a 150-minute lecture with **required attendance**.
  - (online) On Mondays at 9am ET, there will be a 1-week ICPC weekly practice contest.
  - (online) From Fridays to Sundays, there will be a 48-hour ICPC weekend practice contest.
  - (online) Throughout the week, there will be a Codeforces contest.

Grade Breakdown

- **(40%)** Weekly Live Contests (Your points out of 150 points, uncapped)
- **(20%)** Weekly Presentation in Class
- **(20%)** Weekly Practice Contests (1% per each attended practice contest; .5% per each extra practice contest, uncapped)
- **(20%)** Weekly 1:1 Mentorship (2% per each mentorship session)

- Please take a look at syllabus for approximate time commitment, grade distribution, policy on academic honesty, and potential topics.

Automatic Failure Modes

- Here are the modes in which the final grade will result in automatic failure of the course:
  - Failure to present in the lecture;
  - Failure to participate in the contest with a proper citation;
  - Failure to meet in 1:1 mentorship;
  - Failure to attend the lecture;
  - Failure to adhere to Course Contract;
  - Failure to submit Course Contract;

More on Course Syllabus!

- Please take a look at the **syllabus** carefully, as some important additional information is covered in the syllabus such as:
  - Grade Distribution;
  - Policy on Academic Honesty;
  - Detailed Lesson Plan and Key Dates;

Important Note

- Do **<u>NOT</u>** be AFRAID to ask! I **love** students asking questions.

- I am here to make you all succeed in this class and in the actual programming contest.

- Once you do that, convincingly passing interview will almost come for free.

Important Note

- You can think of me as a **coach** rooting for your success in life.

- So, let's pull this through together; I will lead you through this journey!

- **Welcome** to the world of competitive programming!

- You are now signing up as one of the true competitive programming **warriors**!

Questions so far?

- Let's take a **5-minute** break!

Lecture Formats

- Each lecture will be divided into two parts: **Part A** and **Part B**.

- **Part A** will always be a lecture.
- **Part B** will always be a presentation slot
  - Exception:
    - The first lecture on September 11;
    - The last lecture on December 11;

September 2023

Dates	Topics
September 11, 2023	**Lecture 1-a**: Logistics; Expectations; **Lecture 1-b**: Practice Strategies; Contest Strategies; ICPC Preparation; C++ Languages; I/O;
September 18, 2023	**Lecture 2-a**: Data Structure: Built-in Libraries
September 25, 2023	**Lecture 3-a**: Data Structure: Disjoint Set and Segment Trees

September 2023

October 2023

Dates	Topics
October 2, 2023	**Lecture 4-a**: Complete Search and Divide and Conquer
October 9, 2023	**Lecture 5-a**: Greedy and Dynamic Programming
October 16, 2023	**Lecture 6-a**: Graphs I: Shortest Paths and Spanning Trees
October 23, 2023	**Lecture 7-a**: Graphs II: LCA, Flow, and Matchings
October 30, 2023	**Lecture 8-a**: Mathematics I: Ad Hoc and Combinatorics

October 2023

November 2023

Dates	Topics
November 13, 2023*	**Lecture 9-a**: Mathematics II: Number Theory and Games
November 20, 2023	**Lecture 10-a**: Strings I: Fundamentals
November 27, 2023	**Lecture 11-a**: Strings II: Suffix Automaton

November 2023

December 2023

Dates	Topics
December 4, 2023	**Lecture 12-a**: Geometry: Fundamentals and Convex Hull
December 11, 2023	**Lecture 13-a**: Rare Topics and Challenges **Lecture 13-b**: Conclusion and Next Steps

December 2023

Success Pathways

- Those who are just starting should focus on the **first half** of problems in Zealot Problem Set. Your main focus should be gaining some experiences with an explicit goal to enjoy the process of solving new problems and potentially making it to the ICPC North America Championship (NAC)!

- Those who are more serious should focus on the **second half** of problems in Zealot Problem Set. Your goal should be making into the World Finals and potentially winning a medal!

Practice Strategies

- If your goal is to get to a rating of **X**, you should practice on problems that are **X + 300** typically, with a spread of 100. So, picking problems within the range of:

$$\{X + 200, X + 300, X + 400\}$$

  would be sensible!

- So, if you want to target becoming a **red**, which has a lower-bound of 2400, you should aim to solving {2600, 2700, 2800}.
- **(Eventual) Target**: You should focus on solving it for 30 minutes or less!

Practice Strategies

- You should focus on solving each problem for **30 minutes or less**; if you cannot solve any problem with this range, you should consider solving a problem with a lower rating.

- You should aim to solve **10 ~ 15 problems** each day within this range to expect a rank up within a quarter (3 months).

Practice Strategies

- If you cannot solve a problem, here is a sample recipe you can follow:
    - Look at editorial for hints, and try to solve the problem.
    - Look at editorial for full solutions, and try to solve the problem.
    - Look at accepted solutions, and try to solve the problem.
    - Make sure you look back after two weeks and see if you can solve it.

Live Contest Strategies

- **A Terse Guide to Live Contests**

ICPC Preparation

- **A Terse Guide to ICPC Preparation**

C++ Tips and Tricks: best to learn those through practice!

- **C++ Tricks** (HosseinYousefi)
- **C++ tips and tricks** (Golovanov399)
- **Some Tips for Coding in C++ in Competitive Programming** (Nea1)

- Use "**#include <bits/stdc++.h>**" header to include **almost everything**.

Standard Input/Output (stdio)

- **Yet again on C++ input/output** (andreyv)

- **scanf/printf** vs **cin/cout**
  - Often, use "ios::sync_with_stdio(0); cin.tie(0); cout.tie(0);"

Sample Problem (Warm-Up)

- Suppose you want to reach a target **node t** from a source **node s** where the edge weights are all unit and bidirectional.
- Report the minimum cost to reach **node t** from **node s**, or return **-1** if **node t** is unreachable from **node s**.

Solution

- **Breadth First Search** (BFS)

Code

```cpp
int bfs(vector<vector<int>> &adj, int s, int t) {
    queue<int> q; q.push(s);
    map<int,int> dist; dist[s]=0;
    while(!q.empty()) {
        int cur=q.front(); q.pop();
        if(cur==t) return dist[t];
        for (auto nxt : adj[cur]) {
            if(dist.count(nxt)) continue;
            dist[nxt]=dist[cur]+1; q.push(nxt);
        }
    }
    return -1;
}
```

Presentation Slots

- Please sign up for the presentations for **Monday, September 18**: **https://bit.ly/fall-2023-columbia-cp-presentation**

- **Sample slide deck**

Course Basic Entry Requirement

- (LeetCode Weekly or Biweekly LIVE Contest 3 problems or more

OR

- CodeForces Division 2 1 problem or more)

AND

- A short 1:1 fit interview with your resume

ICPC World Finals @Egypt!

- **Kevin Yang (yangster67)**, **Kaiheng Dai (askd)**, and **Neal Lai (Nea1)** are representing Columbia University in ICPC World Finals at Egypt!

- Due to a travel to Egypt for ICPC World Finals in November, a lecture on November 13 will be online, potentially asynchronously.

- I will make sure to clarify how it will work closer to the dates. Thanks for your understanding!

Reminder!

- Do as **MANY** CodeForces contests as you can!
- **Submit Course Contract by this Friday!**

- Join the following discord servers!
  - [ICPC GNYR] **https://discord.gg/nb4f2brKdw**
  - [Programming Zealots] **https://discord.gg/7bvMnMyF6G**
  - [Quant Warriors] **https://discord.gg/4v2rUXyst9**
  - [ICPC Training Warriors] **https://discord.gg/mAUGf3Zxx8**
  - [Problem Solving Warriors] **https://discord.gg/HEkTf9RhME**

In closing…

- As you can see, we have **A LOT** of topics to cover…
- So, the focus will be on learning algorithm in terms of its:
    - core/essential ideas
    - implementation details
    - application
- The explicit non-goals are:
    - proofs
    - rigorous treatments
- **Welcome** to the world of competitive programming!
- Learning together, you will find the topics are actually (easily?) learnable!!

THANK YOU